BGE

Calvert Cliffs Nuclear Power Plant

License Renewal Project

Aging Management Review Report

for the

Auxiliary Building

Revision 2

May, 1996

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LIST OF EFFECTIVE PAGES

Revision	Pages	Summary of Change
0	All	Initial revision prepared using LCM-10S, Revision 1.
1	All	Changes made to reflect disposition of Technical Problem Reports written against Revision 0 and to correct transcription errors between the results and the final report sections.
2	All	Wording changes to make the language in the final report sections more consistent with the language used in the Integrated Plant Assessment Methodology. Also, technical changes regarding the aging management strategy used to address degradation effects associated with corrosion in structural steel.

1.0 INTRODUCTION

1.1 AUXILIARY BUILDING DESCRIPTION

This section describes the scope and boundaries of the Auxiliary Building as it was evaluated. Section 1.1.1 provides a brief synopsis of the Auxiliary Building as described in existing plant documentation. The Auxiliary Building boundary is defined in Section 1.1.2 to clarify the portions of the structure considered in this evaluation. Section 1.1.3 is a detailed breakdown of the Auxiliary Building intended functions for license renewal and is provided as a basis for component scoping and the identification of component-specific functions.

1.1.1 Auxiliary Building LCM Description

The Auxiliary Building is a Class 1 structure, located between the Unit-1 and Unit-2 Containment Class 1 structures and adjacent to the Turbine Building. The Auxiliary Building is primarily a reinforced concrete structure with a mat foundation that supports a structural steel and reinforced concrete frame which consists mainly of reinforced concrete walls and floors. On the top of the structure, over the fuel handling area, is a secondary steel frame structure with missile resistant concrete walls and roof, which houses the Spent Fuel Cask Handling Crane.

1.1.2 Auxiliary Building LCM Boundary

The Auxiliary Building structure and its structural components provide support and shelter to safety related and non-safety related equipment inside the Auxiliary Building. The LCM boundary addressed by this scoping and evaluation included all in-Auxiliary Building structural components serving such functions but did not include commodity items such as pipe support and snubbers. Structural components within the Auxiliary Building include supports for the following major device types:

Accumulators (ACCUMU), compressors (COMP), fans (FAN), heat exchangers (HX), motors (MOTOR), motor control centers (MCC), pumps (PUMP), emergency diesels (GEN), demineralizer (DEMIN), tanks (VESSEL).

Also included in the Auxiliary Building boundary are structural or functional supports for non-safety related equipment of the above device types. During an abnormal event such as a seismic event, failure of these

non-safety-related equipment supports must not adversely affect the operability of other safety related components.

1.1.3 Auxiliary Building Intended Functions

A detailed review of the Auxiliary Building intended functions was completed during the scoping process described in the BGE Integrated Plant Assessment Methodology. The following functions for the Auxiliary Building were identified as structural intended functions on Table 1S of "Component Level Scoping Results for the Auxiliary Building."

1.1.3.1 Function LR-S-1

Provides structural and/or functional support, or both, to safety-related equipment.

1.1.3.2 Function LR-S-2

Provides shelter/ protection to safety-related equipment (Including HELB and Radiation Protection).

1.1.3.3 Function LR-S-3

Serves as a pressure boundary or fission product retention barrier to protect public health and safety in the event of any postulated DBEs.

1.1.3.4 Function LR-S-4

Serves as a missile barrier (internal or external).

1.1.3.5 Function LR-S-5

Provides structural and/or functional support to non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the intended safety-related functions.

1.1.3.6 Function LR-S-6

Provides flood protective barrier (internal flooding event).

1.1.3.7 Function LR-S-7

Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

1.2 EVALUATION METHODS

Auxiliary Building structural components within the scope of license renewal were evaluated in accordance with BGE procedure EN-1-305[1], Revision 0, "Component Aging Management Review Procedure for Structures." The results of these evaluations are summarized in Sections 3.0 through 5.0.

1.3 AUXILIARY BUILDING SPECIFIC DEFINITIONS

This section provides the definitions for any specific terms unique to the Auxiliary Building structural component level evaluation.

Term	Definition
None	N/A

1.4 AUXILIARY BUILDING SPECIFIC REFERENCES

References utilized in the completion of the Auxiliary Building structural component level evaluation are listed in Table 1-1. Drawings and procedures used as source documents in the evaluation were taken at the revision level of record at the start of this task which was October 1994. The updates performed in Revisions 1 and 2 of this report incorporated several TPRs. The update performed in Revision 2 was performed to address a new strategy in the aging management of corrosion effects on structural steel. Only references affected by the Revision 1 and Revision 2 updates were revised.

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1 Revision 0 and Revision 1 were done to LCM-10S. EN-1-305 is new version of LCM-10S which updated procedure format and terminology only.

Table 1-1

Auxiliary Building Specific References

Document ID.	Document Title	Revision No.	Date	Type
UFSAR	Calvert Cliffs Nuclear Power Plant Units 1 and 2, Updated Final Safety Analysis Report	16	1994	Report
Technical Specification	Calvert Cliffs Nuclear Power Plant, Units 1 and 2, Technical Specification	182 159	9/93 9/93	Report
—	Component Level Scoping Results for the Auxiliary Building	1	1996	Report
EPRI RP-2643-27	Class I Structures License Renewal Industry Report	—	12/91	Report
—	Component Evaluation and Program Evaluation Results for Containment System No. 59	2	1996	Report
—	Mather, B., "How to Make Concrete that will be immune to the effects of freezing and thawing," ACI Fall Convention, San Diego	—	11/89	Paper
—	Troxell, G.E., Davis, H.E., and Kelly, J.W., "Composition and Properties of Concrete," McGraw Hill	2nd Edition	1968	Text
ASTM C33-82	"Standard Specification for Concrete Aggregates," American Society of Testing and Materials	—	1982	Spec
—	Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2, by Bechtel Power Corp.	0	8/91	Guide
6750-C-9	Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2	8	4/70	Spec
ACI 318-63	"Building Code Requirements for Reinforced Concrete," American Concrete Institute	—	1963	Code
ACI 201.2R-67	"Guide to Durable Concrete," American Concrete Institute	—	1967	Standard
—	"Concrete Manual," U.S. Department of the Interior	8th Edition	1975	Code
6750-C-23E	Specification for Furnishing and Installation of Piezometer - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2	0	11/73	Spec
ASTM C-289-66	"Potential Reactivity of Aggregates (Chemical Method)," American Society of Testing and Materials	—	1966	Code
ASTM C-295-65	"Petrographic Examination of Aggregates for Concrete," American Society of Testing and Materials	—	1965	Code
—	Letter from Charles County Sand & Gravel Co. to Bechtel Corp.	—	6/72	Letter
—	Skoulikidas, T., Tsakopoulos, A., and Moropoulos, T., "Accelerated Rebar Corrosion When Connected to Lightning Conductors and Protection of Rebars with Needles Diodes Using Atmospheric Electricity," in Publication ASTM STP 906, "Corrosion Effects of Stray Currents and the Techniques for Evaluating Corrosion of Rebars in Concrete"	—	—	Paper
ACI-209R-82	"Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures," American Concrete Institute	—	1982	Standard

Table 1-1

Auxiliary Building Specific References

Document ID.	Document Title	Revision No.	Date	Type
—	"Design and Control of Concrete Mixtures," Portland Cement Association	11th Edition	7/68	Guide
IAEA-TECDOC-670	"Pilot Studies on Management of Aging of Nuclear Power Plant Components," International Atomic Energy Agency	—	10/92	Report
MN-3-100	Painting and Other Protective Coatings	0	9/94	Procedure
TRD-A-1000	Coating Application Performance Standard	8	8/91	Spec
6750-A-24	Specification for Painting and Special Coatings	12	10/82	Spec
6750-C-31	Specification for Furnishing, Detailing, Painting, and Delivering Containment and Auxiliary Building Structural Steel	2	5/70	Spec
ACI 215R-74	"Consideration for Design of Concrete Structures Subjected to Fatigue Loading," American Concrete Institute	—	1986	Standard
—	"Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," American Institute of Steel Construction	—	1963	Spec
—	Brockengrough, R.L., and Johnson, B.G., "Steel Design Manual," United States Steel Corporation	—	5/74	Text
6750-C-28	Specification for Stainless Steel Liner Plate and Spent Fuel Pool Bulkhead Gate	5	6/73	Spec
NUREG/CR4652, ORNL/TM-10059	Naus, D.J., "Concrete Component Aging and its Significance Relative to Life Extension of Nuclear Power Plants," Oak Ridge National Laboratory, Oak Ridge, TN	—	9/86	Paper
ACI 349-85	"Code Requirements for Nuclear Safety Related Concrete Structures," American Concrete Institute	—	1985	Code
—	EQ Design Manual, Calvert Cliffs Nuclear Power Plant	17	1992	Guide
6750-A-2	Specification for Furnishing, Delivery and Erection of the Building Masonry	1	9/70	Spec
ASME Section III, Division 2	"Code for Concrete Reactor Vessels and Containments," American Society of Mechanical Engineers Boiler and Pressure Vessel Code	—	1986	Code
62-149-E	Appendix "R" Separation Requirements, Aux. Bldg. and Ctmt. Sruct., Elevations (-)10'-0" and (-)15'-0"	5	10/93	Drawing
62-150-E	Appendix "R" Separation Requirements, Aux. Bldg. and Ctmt. Sruct., Elevations 5'-0"	6	5/94	Drawing
62-151-E	Appendix "R" Separation Requirements, Aux. Bldg. and Ctmt. Sruct., Elevations 27'-0"	6	5/94	Drawing
62-152-E	Appendix "R" Separation Requirements, Aux. Bldg. and Ctmt. Sruct., Elevations 45'-0"	7	5/94	Drawing
62-153-E	Appendix "R" Separation Requirements, Aux. Bldg. and Ctmt.	7	5/94	Drawing

Table 1-1

Auxiliary Building Specific References

Document ID.	Document Title	Revision No.	Date	Type
	Sruct., Elevations 69'-0"			

2.0 STRUCTURAL COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL

The Auxiliary Building components were scoped in accordance with the process described in the BGE Integrated Plant Assessment Methodology. The Auxiliary Building was scoped using procedure LCM-11S for structural components. The purpose of the scoping is to identify all structural components that provide one of the structure's intended functions identified in Section 1.1.3. These structural components are designated as within the scope of license renewal.

As a result of the scoping, 37 structural component types were designated as within the scope of license renewal. A summary of the scoping result is in Table 2-1.

Table 2-1

Auxiliary Building Structural Components Within the Scope of License Renewal

COMPONENT TYPE	INTENDED FUNCTION(S)
Foundations(Footings, Beams, and Mats)	LR-S-1 and 5
Concrete Column	LR-S-1 and 5
Concrete Walls	LR-S-1, 2, 4, 5, 6, and 7
Concrete Beams	LR-S-1 and 5
Concrete Ground Floor Slabs	LR-S-1 and 5
Equipment Pads	LR-S-1 and 5
Elevated Floor Slabs	LR-S-1, 2, 5, and 7
Roof Slabs	LR-S-2 and 4
Cast-in-Place Anchors	LR-S-1
Grout	LR-S-1 and 5
Concrete Blocks (Shielding)	LR-S-2
Fluid Retaining Walls and Slabs	LR-S-1
Masonry Block Walls	LR-S-1, 2, 5, 6, and 7
Post-Installed Anchors	LR-S-1, and 5
Steel Columns	LR-S-1 and 5
Steel Beams	LR-S-1 and 5
Baseplates	LR-S-1 and 5
Floor Framing	LR-S-1 and 5
Roof Framing	LR-S-1, 4, and 5
Roof Truces	LR-S-1, 4, and 5
Steel Bracings	LR-S-1 and 5
Platform Hangers	LR-S-1 and 5
Decking	LR-S-1 and 5
Jet Impingement Barriers	LR-S-2
Steel Liners	LR-S-3
Fire Doors, Jambs, and Hardware	LR-S-7
Access Doors, Jambs, and Hardware	LR-S-2
Caulking and Sealants	LR-S-2, 6, and 7
Watertight Doors	LR-S-6 and 7
Lead Brick Shielding	LR-S-2
Roll-up Doors	LR-S-2
New Fuel Rack Assembly	LR-S-1
Monorail	LR-S-5
Cask Handling Crane Rail/Supports	LR-S-1 and 5
Pipe Whip Restraints	LR-S-2
Expansion Joints	LR-S-2 and 7
Spent Fuel Storage Racks	LR-S-1

3.0 STRUCTURAL COMPONENTS PRE-EVALUATION

Per the BGE Integrated Plant Assessment Methodology, the pre-evaluation task is not conducted on structures. Structural components are assumed to be passive and long-lived and therefore subject to an Aging Management Review. Consequently, Table 2-1 also represents a list of structural component types subject to Aging Management Review.

4.0 STRUCTURAL COMPONENTS AGING EFFECTS EVALUATION

4.1 EVALUATION

The evaluation of the Auxiliary Building structural components within the scope of license renewal was completed in accordance with BGE procedure, "Component Aging Management Review Procedure for Structures", EN-1-305, Revision 0. This procedure evaluated all 37 component types identified in Section 2.1 The evaluation accomplished the following:

(1) Identified POTENTIAL aging mechanisms for each structural component type.

(2) Identified PLAUSIBLE component aging mechanisms for each structural component type or specific components within the component type based on the following:

- environmental conditions
- material of construction
- impact on intended functions

(3) Developed attributes for programs to manage the effects of aging from those aging mechanisms identified as PLAUSIBLE.

(4) Evaluated program adequacy to demonstrate that the effects of aging will be managed so that the intended function(s) will be maintained for the period of extended operation.

These steps are discussed in greater detail in the sections that follow.

4.2 AGING MECHANISMS

4.2.1 Potential Aging Mechanisms

This step of the aging evaluation identifies aging mechanisms that are considered to be POTENTIAL for a given component type. An aging mechanism is considered POTENTIAL for a structural component if the evaluation concludes that the aging mechanism could occur in generic applications of the structural component type throughout the plant due to susceptible materials of construction and conducive environmental service conditions.

A comprehensive list of 18 aging mechanisms was developed that may be applicable to structural component types. This was based on the EPRI industry reports prepared for the PWR containment structure and Class I structures.

Other references used to prepare this list include the following:

- NRC NPAR Reports
- IAEA Reports
- DOE Reports

The list of aging mechanisms and materials they affect are in the first column of Table 4-1. The specific description of each is provided in Attachment 1 of procedure EN-1-305 or is described in detail in Section 1.0 of the corresponding appendices (A through T) in the aging management review results.

Each aging mechanism was evaluated for applicability (i.e., POTENTIAL) to the structural component type based on its material of construction and the environmental conditions where the component type could be located. This approach ensures all the components within a component type will be evaluated if the potential of degradation exists.

The results of the structural component type POTENTIAL scoping of the component list of aging mechanisms are presented in Table 4-1.

4.2.2 Component Grouping

The grouping of structural components is primarily based on their materials and their special functions, if any, that contribute to safety, or in the opinion of the evaluator, warrant special attention. The components are grouped into four categories:

(1) Concrete (including reinforcing steel)

(2) Structural steel

(3) Architectural items such as doors, roofing materials, and protective coatings

(4) Additional components that may have an unique function in the structure

4.2.3 Plausible Aging Mechanisms

The identification of PLAUSIBLE aging mechanisms is accomplished through a careful review of the POTENTIAL aging mechanism list, the development of which is discussed in Section 4.2.1. A potential aging mechanism is considered plausible if when it is allowed to continue without any additional preventative or mitigative measures, the aging mechanism would result in the structural component not being able to perform its intended function. An aging mechanism is also considered plausible if there is insufficient evidence to conclude that future degradation will have no impact on the intended functions of the Auxiliary Building structural component. The plausibility determination is made through a careful consideration of all the factors required to allow the aging degradation to occur. In particular, the aging mechanism is scoped for plausibility on the basis of:

- Material of construction
- Environmental service conditions
- Design and construction considerations
- Impact on intended functions
- Physical conditions of the component

The results of the aging mechanism plausibility scoping is an aging mechanism-component matrix listing the aging mechanism and its disposition. The aging mechanism matrix developed for each structural component type is included in Attachment 2 in the evaluation results.

Aging mechanisms determined to be PLAUSIBLE are provided specific aging management recommendations to mitigate the detrimental effects on the structural components. Table 4-2 summarizes the results of the plausibility determination and recommendations for the Auxiliary Building structural components.

4.2.4 Aging Management Program Identification

Once plausible aging mechanisms have been identified, the evaluation is continued to determine whether existing plant programs adequately address the effects of aging for license renewal. If no changes would be needed to existing programs to enable them to manage the effects of aging during the period of extended operation, no further action is required for this aging mechanism. If existing programs would not manage the effects

of aging during the period of extended operation, an age related degradation inspection could be conducted, modifications could be made to existing programs, or new programs could be initiated to adequately manage the effects of aging. This evaluation did not include a determination of whether recommended changes to existing programs or new program recommendations would actually be implemented or which programs would be included in the FSAR Supplement.

4.2.5 Aging Management Recommendations

The evaluation of all structural component types in the Auxiliary Building identified a total of 13 aging mechanisms that have the POTENTIAL to degrade these components. A detailed review of the specific component intended functions, material of construction and its basis of design and construction identified PLAUSIBLE component aging mechanisms as shown in the second column of Table 4-2. In some cases, the conclusion that the aging mechanism is PLAUSIBLE was made because the condition of the component was not available or could not be readily verified due to lack of accessibility.

Recommended aging management activities include actions to perform condition assessment, to verify conditions conducive to degradation do not exist, and to develop inspection and monitoring programs to ensure degradation can be detected and corrective actions can be taken.

The following is a summary of the recommendations:

(1) Verify the water chemistry of groundwater and initiate follow on activities, as necessary, based on test results.

(2) Continue visual inspection of coated structural steel components in accessible areas.

(3) Develop an age related degradation inspection program for coated surfaces of structural steel components that are not readily accessible.

(4) Continue monitoring under the Appendix R Program caulking and sealants and expansion joints that serve as rated fire barriers.

(5) Develop a new program to address the inspection and maintenance of caulking and sealants and expansion joints that do not serve as fire barriers.

Table 4-1

List of Potential Aging Mechanisms for Auxiliary Building Structural Components

Aging Mechanism Description	Potential to Affect Auxiliary Building?	Materials Affected
Freeze-Thaw	Yes	Concrete
Leaching of Calcium Hydroxide	Yes	Concrete
Aggressive Chemicals	Yes	Concrete
Reaction with Aggregates	Yes	Concrete
Corrosion in Embedded Steel/Rebar	Yes	Steel, Concrete
Creep	No	Concrete
Shrinkage	No	Concrete
Abrasion and Cavitation	No	Concrete
Cracking of Masonry Block Walls	Yes	Block Walls
Settlement	Yes	Structure foundation
Corrosion in Steel	Yes	Steel
Corrosion in Liner	Yes	Steel Liners (Carbon and Stainless)
Corrosion in Tendons	No *	Steel
Prestressing Losses	No *	Steel
Weathering	Yes	Caulking and Sealants, Expansion Joints
Elevated Temperature	Yes	Concrete
Irradiation	Yes	Concrete, Steel
Fatigue	Yes	Concrete, Steel

* There are no Tendons in the Auxiliary Building

Table 4-2

Auxiliary Building Aging Effects Evaluation Summary

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISM	RECOMMENDATION	REMARKS
Concrete Columns	None	None	See justification in Appendices D, R, S, and T.
Concrete Beams, Roof Slabs	None	None	See justification in Appendices D, S, and T.
Ground Floor Slabs & Equipment Pads	None	None	See justification in Appendices D, R, S, and T.
Elevated Floor Slabs	None	None	See justification in Appendices D, R, S, and T.
Cast-in-place Anchors	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendices K.
Grout	None	None	See justification in Appendices R, S, and T.
Post-installed Anchors	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Steel Columns	Corrosion in steel	All exposed surfaces of structural steel components are covered by a protective coating. For accessible areas, significant coating degradation and/or the presence of corrosion will be identified, an issue report written, and corrective action taken through the following existing site programs. PEG-7, System Walkdowns QL-2-100, Issue Reporting MN-3-100, Protective Coating Program For those structural steel components not readily accessible, significant coating degradation and/or the presence of corrosion will be determined utilizing an age related degradation inspection.	See justification in Appendix K.
Steel Beams	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Baseplates	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Floor Framing	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.

Table 4-2

Auxiliary Building Aging Effects Evaluation Summary

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISM	RECOMMENDATION	REMARKS
Roof Framing/Trusses	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Steel Bracings	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Platform Hangers	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Decking	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Jet Impingement Barriers	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Pipe Whip Restraints	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Monorail	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Cask Handling Crane Rail/Supt	Corrosion in steel	See recommendation for "Steel Columns"	See justification in Appendix K.
Expansion Joints	Weathering	Expansion joints which perform a fire barrier function will be addressed by the Appendix R Program. For expansion joints which perform an intended function other than fire barrier, an inspection and maintenance program which will identify degradation and ensure corrective action is taken before the component losses its ability to perform its intended function will be developed. The resolution to Issue Report IR1995-01698 will form the basis for this program.	See justification in Appendix O.
Caulking and Sealants	Weathering	Caulking and sealants which perform a fire barrier function will be addressed by the Appendix R Program. For caulking and sealants which perform an intended function other than fire barrier, an inspection and maintenance program which will identify degradation and ensure corrective action is taken before the component losses its ability to perform its intended function will be developed. The resolution to Issue Report IR1995-01698 will form the basis for this program.	See justification in Appendix O.

Table 4-2

Auxiliary Building Aging Effects Evaluation Summary

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISM	RECOMMENDATION	REMARKS
Concrete Walls	Aggressive chemical corrosion in embedded steel/rebar	See recommendation for "Foundation Mat"	Aging mechanisms are plausible only for the below grade portion of the Auxiliary Building walls. See justification in Appendices A, B, C, D, E, R, S, and T.
Foundation Mat	Aggressive chemical corrosion in embedded steel/rebar	The observation wells, installed during construction, can be restored to monitor the groundwater fluctuation and to sample the groundwater for water quality testing. This data will be used to evaluate the impact of chemical attacks on the exterior surface of the components. In cases where the groundwater chemistry investigation determines that degradation of the foundation mat is plausible (such as a pH less than 4.0), additional investigations or inspections may be required.	See justification in Appendices B, C, D, E, J, S, and T.
Fluid Retaining Walls & Slabs	None	None	See justification in Appendices D, and S.
Spent Fuel Storage Racks	None	None	See justification in Appendix L.
Steel Liner (SS Spent Fuel Pool Liner)	Corrosion in liner	None	See justification in Appendix L.
New Fuel Rack Assembly	Corrosion in Steel	See recommendation for "steel columns"	See justification in Appendix K
Fire Doors, Jambs, and Hardware	Corrosion in Steel	See recommendation for "steel columns"	See justification in Appendix K
Access Doors, Jambs, and Hardware	Corrosion in Steel	See recommendation for "steel columns"	See justification in Appendix K
Roll-Up Doors	Corrosion in Steel	See recommendation for "steel columns"	See justification in Appendix K
Watertight Doors	Corrosion in Steel	See recommendation for "steel columns"	See justification in Appendix K

Table 4-2

Auxiliary Building Aging Effects Evaluation Summary

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISM	RECOMMENDATION	REMARKS
Lead Brick Shielding	None	None	Lead is not subject to any aging mechanisms noted in Appendices A to T.
Concrete Blocks (Shielding)	None	None	See justification in Appendix I
Masonry Block Walls	None	None	See justification in Appendix I

5.0 PROGRAM EVALUATION

5.1 PROGRAM ADEQUACY EVALUATION

Program adequacy evaluations were completed in accordance with EN-1-305, Revision 0, for those programs or aging degradation management alternatives developed to address PLAUSIBLE component aging mechanisms The evaluation of programs or aging management alternatives considered the following criteria as a means of establishing the adequacy of specific CCNPP programs:

1. Adequate programs must ensure management of the effects of aging for those structural components subject to plausible aging mechanisms.
2. Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.
3. Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.

The results of the program adequacy evaluations are provided in Section 5.2.

5.2 STRUCTURAL COMPONENTS SUBJECT TO ADEQUATE PROGRAMS

5.2.1 Existing Programs

The program evaluation task reviewed all existing CCNPP programs that were established to monitor, inspect, and repair Auxiliary Building structural components that are degraded by identified plausible aging mechanisms.

Procedure OI-24D and Performance Evaluation, PE 0-67-2-O-M, for the monitoring of leakage in the Spent Fuel Pool, can be relied on to manage the effects of aging without any modifications.

The Appendix R Program, implemented through procedure STP-F-592-1/2 for penetration fire barrier inspection, is adequate to manage the effects of aging for caulking and sealants and expansion joints which function as fire barriers without any modification.

PEG-7 in combination with QL-2-100 and MN-3-100 for identifying, documenting, and correcting significant coating degradation are adequate for managing the effects of corrosion in accessible steel components.

5.2.2 Modified Existing Programs

This section provides the summary results for those structural components that were determined to have an existing CCNPP Program/Activity that with modification would become an adequate program to manage the effects of aging during the renewal period. The evaluation started from evaluating structural component types and applicable aging mechanisms and has focused to specific components or locations. No modified existing programs were identified to manage the effects of aging into the license renewal period.

5.2.3 New Programs

This section provides the summary results for those structural components that were determined to require a new CCNPP Program/Activity to be created as an adequate program to manage the effects of aging during the renewal period. Components that can be managed by the creation of such new programs include the following:

Below grade portion of Auxiliary Building wall: An investigative program starting with testing the groundwater chemistry should be developed to determine if there is any aggressive chemical attack on the Auxiliary Building exterior walls or plausible corrosion in embedded steel/rebar. Inspection of the exterior, below grade surfaces and additional excavation and testing may be necessary if results from the investigative tests are not favorable.

Foundation Mat: An investigative program starting with testing the groundwater chemistry should be developed to determine if there is any aggressive chemical attack on the foundation mat or plausible corrosion in embedded steel/rebar. Inspection of the exterior, below grade surfaces and additional excavation and testing may be necessary if results from the investigative tests are not favorable.

Caulking and Sealants and Expansion Joints: A periodic inspection and maintenance program should be developed for components not covered by the Appendix R fire barrier inspection program. The resolution to Issue Report IR1995-01698 will address the requirements for the inspection and maintenance of caulking and sealants and expansion joints which do not function as fire barriers and are therefore not covered by the Appendix R Program.

Non-accessible Structural Steel: An age related degradation inspection, as defined in the BGE Integrated Plant Assessment Methodology, should be conducted for structural steel components that are not readily accessible. The ARDI Program must provide requirements for identification of a representative sample of components for inspection, the inspection sample size, appropriate inspection techniques, and requirements for reporting of results and corrective actions.

List of Attachments and Appendices For the Auxiliary Building Aging Management Review

Attachment 1

Potential Aging Mechanisms Applicable to Structural Components

Potential Aging Mechanisms Applicable to Structural Components

STRUCTURE NAME: Auxiliary Building Structure

REVISION: 2
SYSTEM NUMBER: None

DATE: 5/7/96
Sheet 2 of 3

IN SCOPE STRUCTURAL COMPONENTS	POTENTIAL AGING MECHANISMS APPLICABLE TO CONCRETE/ARCH. COMPONENTS														REMARKS
	A	B	C	D	E	F	G	H	I	J	R	S	T	O		
Foundations (Footings, Beams & Mats)	-	√	√	√	√	-	-	-	NA	√	-	√	–	-		LR Functions LR-S-1, 5
Concrete Columns	-	-	-	√	-	-	-	-	NA	-	√	√	√	-		LR Functions LR-S-1, 5
Concrete Walls	√	√	√	√	√	-	-	-	NA	-	√	√	√	-		LR Functions LR-S-1, 2, 4, 5, 6, 7
Concrete Beams	-	-	-	√	-	-	-	-	NA	-	-	√	√	-		LR Functions LR-S-1, 5
Concrete Ground Floor Slabs	-	-	-	√	-	-	-	-	NA	-	-	√	√	-		LR Functions LR-S-1, 5
Concrete Equipment Pads	-	-	-	√	-	-	-	-	NA	-	√	√	√	-		LR Functions LR-S-1, 5
Elevated Floor Slabs	-	-	-	√	-	-	-	-	NA	-	√	√	√	-		LR Functions LR-S-1, 2, 5, 7
Roof Slabs	-	-	-	√	-	-	-	-	NA	-	-	√	√	-		LR Functions LR-S-2, 4
Grout	-	-	-	-	-	-	-	-	NA	-	√	√	-	-		LR Functions LR-S-1, 5
Concrete Blocks (Shielding)	-	-	-	-	-	-	-	-	√	-	-	√	-	-		LR Function LR-S-2
Fluid Retaining Walls & Slabs	-	-	-	√	-	-	-	-	NA	-	-	√	-	-		LR Function LR-S-1
Masonry Block Walls	-	-	-	-	-	-	-	-	√	-	-	√	-	-		LR Functions LR-S-1, 2, 5, 6, 7
Expansion Joints	-	-	-	-	-	-	-	-	NA	-	-	-	-	√		LR Function LR-S-2, 7
Caulking and Sealants	-	-	-	-	-	-	-	-	NA	-	-	-	-	√		LR Function LR-S-2, 6, 7

Legend:

A	Freeze-thaw	G	Shrinkage	M	Corrosion in tendons	S	Irradiation
B	Leaching of calcium hydroxide	H	Abrasion and cavitation	N	Prestressing losses	T	Fatigue
C	Aggressive chemicals	I	Cracking of masonry block walls	O	Weathering	U	(Not Used)
D	Reaction with aggregates	J	Settlement	P	(Not Used)	V	(Not Used)
E	Corrosion in embedded steel/rebar	K	Corrosion in steel	Q	(Not Used)	NA	Not applicable
F	Creep	L	Corrosion in Liner	R	Elevated temperature	-	Not potential

Potential Aging Mechanisms Applicable to Structural Components

STRUCTURE NAME: Auxiliary Building Structure

REVISION: 2

SYSTEM NUMBER: None

DATE: 5/7/96

IN SCOPE STRUCTURAL COMPONENTS	POTENTIAL AGING MECHANISMS APPLICABLE TO STEEL COMPONENTS (SEE APPENDICES A THROUGH T FOR DEFINITIONS OF AGING MECHANISMS)															REMARKS
	K	L	M	N	R	S	T									
Steel Columns	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Steel Beams	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Baseplates	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Floor Framing	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Roof Framing/Trusses	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 4, 5
Steel Bracings	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Platform Hangers	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Decking	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Jet Impingement Barriers	√	-	NA	NA	-	-	-									LR Function LR-S-2
Steel Liners	-	√	NA	NA	-	-	-									LR Function LR-S-3
Fire Doors,Jambs,& Hardware	√	-	NA	NA	-	-	-									LR Function LR-S-7
Access Doors,Jambs,& Hardware	√	-	NA	NA	-	-	-									LR Function LR-S-2
Watertight Doors	√	-	NA	NA		-	-									LR Functions LR-S-6, 7
Lead Brick Shielding	-	-	NA	NA	-	-	-									LR Function LR-S-2
Roll-up Doors	√	-	NA	NA	-	-	-									LR Function LR-S-2
New Fuel Rack Assembly	√	-	NA	NA	-	-	-									LR Functions LR-S-1
Monorail	√	-	NA	NA	_	_	-									LR Functions LR-S-5
Cask Handling Crane Rail/Spts	√	-	NA	NA	-	-	√									LR Functions LR-S-1, 5
Pipe Whip Restraints	√	-	NA	NA	-	-	-									LR Function LR-S-2
Cast-in-place Anchors	√	-	NA	NA	-	-	-									LR Function LR-S-1
Post-Installed Anchors	√	-	NA	NA	-	-	-									LR Functions LR-S-1, 5
Spent Fuel Storage Racks	-	-	-	-	-	-	-									LR Functions LR-S-1

Legend:

A	Freeze-thaw	G	Shrinkage	M	Corrosion in tendons	S	Irradiation
B	Leaching of calcium hydroxide	H	Abrasion and cavitation	N	Prestressing losses	T	Fatigue
C	Aggressive chemicals	I	Cracking of masonry block walls	O	Weathering	U	(Not Used)
D	Reaction with aggregates	J	Settlement	P	(Not Used)	V	(Not Used)
E	Corrosion in embedded steel/rebar	K	Corrosion in steel	Q	(Not Used)	NA	Not applicable
F	Creep	L	Corrosion in Liner	R	Elevated temperature	-	Not potential

Attachment 2

Plausible Aging Mechanisms Applicable to Structural Components

ATTACHMENT 2: PLAUSIBLE AGING MECHANISMS APPLICABLE TO STRUCTURAL COMPONENTS

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: A·xiliary Building Structure SYSTEM NUMBER: None Sheet 2 of 3

LR STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISMS APPLICABLE TO CONCRETE/ARCH. COMPONENTS (SEE ATTACHMENT 4 FOR JUSTIFICATION)															REMARKS
	A	B	C	D	E	F	G	H	I	J	R	S	T	O		
Foundations (Footings, Beams & Mats)	-	102	PA	103	PB	-	-	-	NA	105	-	107	-	-		
Concrete Columns	-	-	-	103	-	-	-	-	NA	-	106	107	108	-		
Concrete Walls	101	102	PA	103	PB	-	-	-	NA	-	106	107	108	-		
Concrete Beams	-	-	-	103	-	-	-	-	NA	-	-	107	108	-		
Concrete Ground Floor Slabs	-	-	-	103	-	-	-	-	NA	-	-	107	108	-		
Concrete Equipment Pads	-	-	-	103	-	-	-	-	NA	-	106	107	108	-		
Elevated Floor Slabs	-	-	-	103	-	-	-	-	NA	-	106	107	108	-		
Roof Slabs	-	-	-	103	-	-	-	-	NA	-	-	107	108	-		
Grout	-	-	-	-	-	-	-	-	NA	-	106	107	-	-		
Concrete Blocks (Shielding)	-	-	-	-	-	-	-	-	111	-	-	107	-	-		
Fluid Retaining Walls and Slabs	-	-	-	103	-	-	-	-	NA	-	-	107	-	-		
Masonry Block Walls	-	-	-	-	-	-	-	-	111	-	-	107	-	-		
Expansion Joints	-	-	-	-	-	-	-	-	NA	-	-	-	-	PF		
Caulking and Sealants	-	-	-	-	-	-	-	-	NA	-	-	-	-	PF		

Legend:

A Freeze-thaw	G Shrinkage	M Corrosion in tendons	S Irradiation
B Leaching of calcium hydroxide	H Abrasion and cavitation	N Prestressing losses	T Fatigue
C Aggressive cnemicals	I Cracking of masonry block walls	O Weathering	U (Not Used)
D Reaction with aggregates	J Settlement	P (Not Used)	V (Not Used)
E Corrosion in embedded steel/rebar	K Corrosion in steel	Q (Not Used)	NA Not applicable
F Creep	L Corrosion in Liner	R Elevated temperature	- Not potential

ATTACHMENT 2: PLAUSIBLE AGING MECHANISMS APPLICABLE TO STRUCTURAL COMPONENTS

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: Auxiliary Building Structure SYSTEM NUMBER. None Sheet 3 of 3

LR STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISMS APPLICABLE TO STEEL COMPONENTS (SEE ATTACHMENT 4 FOR JUSTIFICATION)														REMARKS
	K	L	M	N	R	S	T								
Steel Columns	PD	-	NA	NA	-	-	108								
Steel Beams	PD	-	NA	NA	-	-	108								
Baseplates	PD	-	NA	NA	-	-	108								
Floor Framing	PD	-	NA	NA	-	-	108								
Roof Framing/Trusses	PD	-	NA	NA	-	-	108								
Steel Bracings	PD	-	NA	NA	-	-	108								
Platform Hangers	PD	-	NA	NA	-	-	108								
Decking	PD	-	NA	NA	-	-	108								
Jet Impingement Barrier	PD	-	NA	NA	-	-	-								
Steel Liners	-	PE	NA	NA	-	-	-								
Fire Doors, Jambs, & Hardware	PD	-	NA	NA	-	-	-								
Access Doors,Jambs,& hardware	PD	-	NA	NA	-	-	-								
Watertight Doors	PD	-	NA	NA	-	-	-								
Lead Brick Shielding	-	-	NA	NA	-	-	-								
Roll-Up Doors	PD	-	NA	NA	-	-	-								
New Fuel Rack Assembly	PD	-	NA	NA	-	-	-								
Monorail	PD	-	NA	NA	-	-	-								
Cask Handling Cranc Rail/Supts	PD	-	NA	NA	-	-	108								
Pipe Whip Restraints	PD	-	NA	NA	-	-	-								
Cast-in-place Anchors	PD	-	NA	NA	-	-	-								
Post-Installed Anchors	PD	-	NA	NA	-	-	-								
Spent Fuel Storage Racks	-	-	NA	NA	-	-	-								

Legend:

A Freeze-thaw	G Shrinkage	M Corrosion in tendons	S Irradiation
B Leaching of calcium hydroxide	H Abrasion and cavitation	N Prestressing losses	T Fatigue
C Aggressive chemicals	I Cracking of masonry block walls	O Weathering	U (Not Used)
D Reaction with aggregates	J Settlement	P (Not Used)	V (Not Used)
E Corrosion in embedded steel/rebar	K Corrosion in steel	Q (Not Used)	NA Not applicable
F Creep	L Corrosion in Liner	R Elevated temperature	- Not potential

Attachment 3

Structural Components

Aging Mechanism Matrix Codes

ATTACHMENT 3

STRUCTURAL COMPONENT - AGING MECHANISM MATRIX CODES

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: Auxiliary Building

SYSTEM NUMBER: None

CODE	JUSTIFICATION	REMARKS
101	See Appendix A	
102	See Appendix B	
103	See Appendix D	
104	See Appendix H	
105	See Appendix J	
106	See Appendix R	
107	See Appendix S	
108	See Appendix T	
109	Not Used	
110	See Appendix L	
111	See Appendix I	

ATTACHMENT 3

STRUCTURAL COMPONENT - AGING MECHANISM MATRIX CODES

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: Auxiliary Building
SYSTEM NUMBER: None

CODE	JUSTIFICATION	REMARKS
PA	See Appendix C	
PB	See Appendix E	
PC	Not Used	
PD	See Appendix K	
PE	See Appendix L	
PF	See Appendix O	

Attachment 4

Aging Management Review Results

Sheet 1 of 4

Attachment 4

SUMMARY OF AGING MANAGEMENT REVIEW RESULTS

REVISION: 2
DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None STRUCTURE NAME: Auxiliary Building

AGING MECHANISMS	COMPONENTS AFFECTED: CONCRETE	COMPONENTS AFFECTED: STEEL	COMPONENTS AFFECTED: ARCH.	PROGRAM/COMMENT
Freeze-Thaw	None	None	None	Not Needed
Leaching of $Ca(OH)_2$	None	None	None	Not Needed
Aggressive Chemicals	1. Below grade portion of Aux. Bldg. walls 2. Foundation Mat	None	None	None existing. Need to investigate ground water.
Reaction with Aggregates	None	None	None	Not Needed
Corrosion of Embedded Steel/Rebar	1. Below grade portion of Aux. Bldg. walls 2. Foundation Mat	None	None	None existing. Need to investigate ground water.
Creep	None	None	None	Not Needed
Shrinkage	None	None	None	Not Needed
Abrasion/Cavitation	None	None	None	Not needed because this aging mechanism does not exist at the Auxiliary Building.
Cracking of Masonry Block Walls	None	None	None	Not Needed
Settlement	None	None	None	Not Needed

Attachment 4

SUMMARY OF AGING MANAGEMENT REVIEW RESULTS

REVISION: 2
DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None STRUCTURE NAME: Auxiliary Building

AGING MECHANISMS	COMPONENTS AFFECTED			PROGRAM/COMMENT
	CONCRETE	STEEL	ARCH.	
Corrosion in Steel	None	All structural steel members	None	PEG-7, MN-3-100, QL-2-100, ARDI.
Corrosion in Liner	None	Sensitized zone of the Spent Fuel Pool Liner	None	Procedure OI-24D, Rev. 0 and Performance Evaluation, PE 0-67-2-O-M
Corrosion in Tendons	None	None	None	Not needed because there are no tendons in the Auxiliary Building
Prestressing Losses	None	None	None	Not needed because there are no tendons in the Auxiliary Building
Weathering	None	None	1. Caulking and Sealants 2. Expansion joints	Appendix R Program for components with fire protection function. For non-Appendix R components, develop an inspection and maintenance program to identify degradation and ensure corrective action is taken. The resolution to Issue Report IR1995-01698 to form the basis of this program.
Elevated Temperature	None	None	None	Not Needed

Attachment 4

SUMMARY OF AGING MANAGEMENT REVIEW RESULTS

REVISION: 2
DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None   STRUCTURE NAME: Auxiliary Building

AGING MECHANISMS	COMPONENTS AFFECTED			PROGRAM/COMMENT
	CONCRETE	STEEL	ARCH.	
Irradiation	None	None	None	Not Needed
Fatigue	None	None	None	Not Needed

Attachment 5

Adequate Program Evaluation

Attachment 5

ADEQUATE PROGRAM EVALUATION

REVISION: 2 DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: All accessible structural steel members

AGING MECHANISM DESCRIPTION: Corrosion of steel

CCNPP PA or Task ID: MN-3-100, PEG-7, QL-2-100

Criteria 1: **Adequate programs must ensure mitigation of the effects of age-related degradation for the SSCs within the scope of license renewal .**

DISCOVERY DESCRIPTION/BASIS:

1. Is there a frequency interval in the PA or Task?

   YES X NO __

   Basis: System Engineer Walkdowns as directed by PEG-7 are conducted periodically as mandated by system performance, plant operating conditions, or as required by plant management. Walkdowns can be job specific or outage related but otherwise typically occur on a monthly basis.

2. Is the frequency interval consistent with industry standards, industry experience, experience unique to Calvert Cliffs, or vendors' recommendations?

   YES X NO __

   Basis: The PEG-7 walkdown frequency is consistent with industry standards and can be modified as necessary to reflect unique plant operating conditions specific to CCNPP.

3. Will the PA or Task be applicable to all structural components under the same component type?

   YES X NO _

   Basis: All coated surfaces in areas that are "reasonably accessible" are visually inspected during the PEG-7 activity.

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM: Corrosion of steel

CCNPP PA or TASK ID: MN-3-100, PEG-7, QL-2-100

Criteria 2: **Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.**

ASSESSMENT/ANALYSIS/CORRECTIVE ACTION DESCRIPTION/BASIS:

1. Does the PA or Task have an action or alert value or condition parameter to determine the need for corrective action?

   YES X NO __

   Basis: There is no quantitative alert value to determine the need for corrective action. PEG-7 allows for degraded coatings to be documented on a checklist which is then used to prioritize corrective actions. MN-3-100 specifies appropriate technical procedures for corrective action based on the coatings service level.

2. Does the action value or condition provide sufficient indication of degradation to ensure that there will not be a functional failure prior to the next PA or Task?

   YES X NO __

   Basis: Conditions adverse to quality and functionality, indications of equipment stress or abuse, safety or fire hazards, and general housekeeping deficiencies are noted during PEG-7 system walkdowns conducted monthly. Structural degradation occurs at a sufficiently slow rate such that monthly inspections would detect degradation before loss of function could occur.

3. Will the action value or condition parameter remain the same during the renewal period ?

   YES X NO __

   Basis: The corrective actions and condition parameters are based on inspection of the surface condition of the painted component. This approach does not need to be revised during the renewal period.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM: Corrosion of steel

CCNPP PA or TASK ID: MN-3-100, PEG-7, QL-2-100

4. Does the PA or Task ensure that corrective action is taken?

YES X NO __

Basis: PEG-7 requires deficiencies to be documented on a system walkdown report. Conditions adverse to quality will result in the initiation of an Issue Report per QL-2-100 requirements. MN-3-100 invokes the appropriate technical procedure to ensure proper application and that a qualified protective coating is used.

5. Does the PA or Task ensure that the corrective action is appropriately scheduled?

YES X NO __

Basis: QL-2-100 assigns a due date for corrective action to occur. The completion date is driven by engineering judgment based on the condition of the degraded coating and its contribution to the component's intended function.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM: Corrosion of steel

CCNPP PA or TASK ID: MN-3-100, PEG-7, QL-2-109

Criteria 3: **Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.**

CONFIRMATION/DOCUMENTATION DESCRIPTION/BASIS:

1. Does the PA or Task have a review/approval process?

   YES X NO __

   Basis: The procedure requires signatures from appropriate levels of supervision (i.e., POSRC, Manager of Calvert Cliffs Nuclear Power Plant, and GSQA) after it is submitted by the responsible engineer.

2. Does the PA or Task have a change/revision process?

   YES X NO __

   Basis: The "RECORD OF REVISION AND CHANGES" of the procedure documents the changes to the procedure.

Attachment 5

ADEQUATE PROGRAM EVALUATION (continued)

STRUCTURE/SYSTEM NUMBER: None STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: Spent Fuel Pool Liner

AGING MECHANISM DESCRIPTION: Corrosion of liner

CCNPP PA or Task ID: OI-24D, Rev. 0, Operating Instructions for the SFP Cooling - Infrequent Operations and PE 0-67-2-O-M

Criteria 1: Adequate programs must ensure mitigation of the effects of age-related degradation for the SSCs identified as within the scope of license renewal.

DISCOVERY DESCRIPTION/BASIS:

1. Is there a frequency interval in the PA or Task?

   YES X NO ___

   Basis: Performance Evaluation, PE 0-67-2-O-M, reference in Section 6.1 of OI-24D requires a monthly inspection of all SFP "telltale valves".

2. Is the frequency interval consistent with industry standards, industry experience, experience unique to Calvert Cliffs, or vendors' recommendations?

   YES X NO ___

   Basis: The one month inspection interval has been on going for many years and, to date, has always met the acceptance criteria of the procedure with respect to leakage from the SFP (less than 1000 cc in a 24 hr period) and is considered acceptable for identifying SFP leakage during the period of extended operation.

3. Will the PA or Task be applicable to all structural components under the same component type?

   YES X NO ___

   Basis: There is only one steel liner (the SFP Liner) in the Auxiliary Building.

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Corrosion of liner

CCNPP PA or Task ID: OI-24D, Rev. 0, Operating Instructions for the SFP Cooling - Infrequent Operations and PE 0-67-2-O-M

Criteria 2: **Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.**

ASSESSMENT/ANALYSIS/CORRECTIVE ACTION DESCRIPTION/BASIS:

1. Does the PA or Task have an action or alert value or condition parameter to determine the need for corrective action?

   YES X NO ___

   Basis: Per Section 6.1.B.10, if leakage rate exceeds 2 cc in a 24 hour period, from any telltale valve, and if boron is detected, an Issue Report to repair the leak will be submitted.

2. Does the action value or condition provide sufficient indication of degradation to ensure that there will not be a functional failure prior to the next PA or Task?

   YES X NO ___

   Basis: Due to the fact that the inspection intervals are short (one month), any leakage between inspections is easily made up by the SFP pump which has a capacity of 160 gpm and is constantly available to make up losses. The Spent Fuel Pool Liner is a fluid retaining boundary only. It does not provide any structural support function. Structural integrity is maintained by the surrounding concrete. Therefore, leakage detection and trending is an acceptable technique for ensuring that the spent fuel pool liner is capable of performing its intended function under all design conditions required by the CLB. The surrounding concrete has been evaluated for the effects of borated water leakage and a determination made that minor leakage will not affect the structural integrity function of the concrete including embedded rebar.

3. Will the action value or condition parameter remain the same during the renewal period?

   YES X NO ___

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Corrosion of liner

CCNPP PA or Task ID: OI-24D, Rev. 0, Operating Instructions for the SFP Cooling - Infrequent Operations and PE 0-67-2-O-M

Basis: The corrective actions and condition parameters prescribed in OI-24D and PE 0-67-2-O-M are based on detecting very small amounts of leaking borated water from the SFP, as discussed above. This approach does not need to be revised during the period of extended operation.

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Corrosion of liner

CCNPP PA or Task ID: OI-24D, Rev. 0, Operating Instructions for the SFP Cooling - Infrequent Operations and PE 0-67-2-O-M

4. Does the PA or task ensure that corrective action is taken?

YES X NO ___

Basis: Operating Instruction 24-D requires an Issue Report to be generated to document the need for repair, if leakage exceeds a certain action value, as noted above.

5. Does the PA or Task ensure that the corrective action is appropriately scheduled?

YES X NO ___

Basis: The Issue Report program (QL-2-100) will insure that action to correct the deficient condition is appropriately scheduled.

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Corrosion of liner

CCNPP PA or Task ID: OI-24D, Rev. 0, Operating Instructions for the SFP Cooling - Infrequent Operations and PE 0-67-2-O-M

Criteria 3: Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.

CONFIRMATION/DOCUMENTATION DESCRIPTION/BASIS:

1. Does the PA or task have a review/approval process?

   YES X NO ____

   Basis: The procedure requires PORC Review and Plant General Manager approval after it is submitted by the responsible engineer.

2. Does the PA or task have a change/revision process?

   YES X NO ____

   Basis: "Preparation and Control of Calvert Cliffs Technical Procedures", PR-1-101, controls the change/revision process of this and all other site technical procedures.

Attachment 5

ADEQUATE PROGRAM EVALUATION

STRUCTURE/SYSTEM NUMBER: None STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: Caulking and Sealants, Expansion Joints

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or Task ID: STP-F-592-1/2

Criteria 1: Adequate programs must ensure mitigation of the effects of age-related degradation for the SSCs identified as within the scope of license renewal.

DISCOVERY DESCRIPTION/BASIS:

1. Is there a frequency interval in the PA or Task?

   YES X NO __

   Basis: Both the Unit 1 and Unit 2 procedures are implemented in accordance with the frequency intervals specified in plant Technical Specification Section 4.7.12.

2. Is the frequency interval consistent with industry standards, industry experience, experience unique to Calvert Cliffs, or vendors' recommendations?

   YES X NO __

   Basis: The frequency interval is consistent with that commonly used in the industry for surveillance of fire barrier penetration seals. The frequency interval has been approved in association with the implementation of the CCNPP Appendix R Program.

3. Will the PA or Task be applicable to all structural components under the same component type?

   YES X NO __

   Basis: The procedure is applicable to fire barrier penetration seals including electrical conduit and cable tray penetration seals, HVAC duct penetration seals, and mechanical pipe penetration seals. The procedure also covers inspection of the fire resistivity of rated walls, ceilings, and floors. Data sheets are provided with the procedure to identify the fire areas requiring inspection.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or Task ID: STP-F-592-1/2

Criteria 2: **Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.**

ASSESSMENT/ANALYSIS/CORRECTIVE ACTION DESCRIPTION/BASIS:

1. Does the PA or Task have an action or alert value or condition parameter to determine the need for corrective action?

   YES X NO __

   Basis: Acceptance criteria is provided for each type of penetration in Attachment A to the Unit 1 and Unit 2 procedures. The acceptance criteria provides the basis for determining the need for corrective action.

2. Does the action value or condition provide sufficient indication of degradation to ensure that there will not be a functional failure prior to the next PA or Task?

   YES X NO __

   Basis: The procedures in both units mandate visual inspection of the penetration fire barriers for indications of degradation or damage. The criteria implemented in the Calvert Cliffs penetration fire barrier surveillance procedures will ensure the fire barriers perform their intended functions at all times. This requirement is implemented in accordance with the requirements of Appendix R and CCNPP Technical Specifications.

3. Will the action value or condition parameter remain the same during the renewal period ?

   YES X NO __

   Basis: Since the surveillance procedures and the acceptance criteria in the procedures are to ensure the availability and the reliability of the fire barrier penetration seals, this acceptance criteria should not be changed during the renewal period.

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or Task ID: STP-F-592-1/2

4. Does the PA or Task ensure that corrective action is taken?

YES X NO __

Basis: In accordance with Sections 5.4, 7.1, and Attachment B of the procedures for both units, any inspection results determined to be unsatisfactory will be reported to the Shift Supervisor for possible Tech Spec required action and to the Fire Protection System Engineer or Fire Protection Engineer for investigation and corrective action.

5. Does the PA or Task ensure that the corrective action is appropriately scheduled?

YES X NO __

Basis: All corrective actions must meet reporting requirements specified in Technical Specification 4.7.12 of both Units 1 and 2.

REVISION: 2 DATE: 5/7/96

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or Task ID: STP-F-592-1/2

Criteria 3: **Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.**

CONFIRMATION/DOCUMENTATION DESCRIPTION/BASIS:

1. Does the PA or Task have a review/approval process?

   YES X NO __

   Basis: This procedure has a review/approval process per EN-4-104.

2. Does the PA or Task have a change/revision process?

   YES X NO __

   Basis: This procedure has a change/revision process per EN-4-104.

Attachment 7

Walkdown Report - CCNPP
Auxiliary Building
November, 1994

Attachment 7

Walkdown Report - CCNPP
Auxiliary Building
November, 1994

Date of Walkdown: 11/16/94

Participants: Ken Classon (Bechtel)

Summary: A Walkdown of the CCNPP Auxiliary Buildings was performed to support the Component Evaluation and Program Evaluation of the Auxiliary Building. Selected areas of the interior and exterior of the structure were inspected, based on their potential for degradation due to aging mechanisms.

Results: The results of the walkdown/inspections are included on the following pages. This information was used as input to the Auxiliary Building structure evaluation, as applicable.

Attachment 7

APPENDIX	AGING MECHANISM	CHARACTERISTICS	COMMENTS
A	Freeze-thaw	Scaling, cracking, spalling	No scaling, cracking, or spalling was observed
B	Leaching of calcium hydroxide	Leachate	No leachate was observed
C	Aggressive chemicals	Spills, discoloration	No spills or discoloration was observed
D	Reaction with aggregates	Map cracking	No map cracking was observed
E	Corrosion in embedded steel/rebar	Cracking, rust staining, spalling	No cracking, rust staining, spalling was observed
F	Creep	NA	Creep is not a potential aging mechanism for this structure
G	Shrinkage	NA	Shrinkage is not a potential aging mechanism for this structure
H	Abrasion and cavitation	Cracking, spalling	Abrasion and cavitation is not a potential aging mechanism for this structure
I	Cracking of masonry block walls	Cracking	No cracking was observed
J	Settlement	Cracking	No cracking or other evidence of settlement was observed

Attachment 7

APPENDIX	AGING MECHANISM	CHARACTERISTICS	COMMENTS
K	Corrosion in steel	Rust	No rust was observed in the areas of inspection, all structures were satisfactorily coated
L	Corrosion in liner	Cracking, pitting	Spent Fuel Pool is filled with water,it was not inspected.
M	Corrosion in tendons	NA	This aging mechanism is not applicable to the Auxiliary Building
N	Prestressing looses	NA	This aging mechanism is not applicable to the Auxiliary Building
O	Weathering	Hardening, cracking, loss of elasticity	Expansion joint material appeared intact and in satisfactory condition
R	Elevated Temperatures	Heat sources	The Unit-1 MSIV room was inspected and no damage due to elevated temperatures was observed
S	Irradiation	Radiation	No damage due to radiation was observed. The Auxiliary Building is, typically, not exposed to high levels of radiation

Attachment 7

LCM WALKDOWN INSPECTION - AUXILIARY BUILDING (Page 5 of 5)

APPENDIX	AGING MECHANISM	CHARACTERISTICS	COMMENTS
T	Fatigue	Vibrating Equipment	The Auxiliary Building contains vibrating equipment. fatigue caused by this equipment was considered in the original design. No cracking or spalling of concrete or concrete equipment pads was observed.

Attachment 8

Attributes in New Program

Attachment 8

ATTRIBUTES IN NEW PROGRAM

REVISION: 2 DATE: May 1996

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: Below grade portion of Auxiliary Building walls and concrete foundation mat

AGING MECHANISM: Aggressive chemicals

APPLICABLE APPENDIX: Appendix C

BACKGROUND: The intended functions of the Auxiliary Building wall and the foundation mat is to provide support, protection, and shelter to safety related and non-safety related equipment inside the Auxiliary Building. Chemical attack is plausible only if the water chemistry of the groundwater has become significantly more aggressive than was originally anticipated.

RECOMMENDED ATTRIBUTES: Since degradation of the below grade portion of the Auxiliary Building walls and the foundation mat would have been plausible only if the water chemistry has become more aggressive, the program proposed will investigate the water chemistry of the ground water. The recommended approaches are:

1. Restore the groundwater observation wells installed during initial plant construction for sampling purpose or verify the integrity of the existing piezometers located adjacent to the Auxiliary Buildings.

2. Using the water source(s) noted above, a one time verification of the groundwater chemistry shall be performed by securing samples of the underground water for water chemistry testing. If the water chemistry meets original design requirements (Cl ions < 500 ppm, SO_4 ions < 1500 ppm,), no further action is necessary.

3. If the water chemistry tests conclude that it is plausible that these concrete components are being degraded by chemical agents, the levels of chemical concentration will need to be assessed to determine the appropriate corrective actions. Additional investigate programs may be required.

Attachment 8

BASIS: Because of the design and construction of the concrete Auxiliary Building, and the knowledge of the water chemistry during the design of the plant (See Specification 6750-C-33), it is unlikely that chemical attack to concrete is a major concern.

Attachment 8

ATTRIBUTES IN NEW PROGRAM (continued)

REVISION: 2　　　　DATE: May 1996

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: Below grade portion of Auxiliary Building walls and foundation mat

AGING MECHANISM: Corrosion of Embedded Steel/Rebars

APPLICABLE APPENDIX: Appendix E

BACKGROUND: The intended functions of the Auxiliary Building walls and the foundation mat is to provide support, protection, and shelter to safety related and non-safety related equipment inside the Auxiliary Building. Corrosion of below grade portion of Auxiliary Building walls and concrete foundation mat is plausible only if they are exposed to an aggressive environment and on a continual basis.

RECOMMENDED ATTRIBUTES: Since degradation of the below grade portion of the Auxiliary Building walls and foundation mat would have been plausible only if the water chemistry has become more corrosive, the program proposed will investigate the water chemistry of the ground water. The recommended approaches are:

1. Restore the groundwater observation wells installed during initial plant construction for sampling purpose or verify the integrity of the existing piezometers located adjacent to the Auxiliary Buildings.

2. Using the water source(s) noted above, a one time verification of the groundwater chemistry shall be performed by securing samples of the underground water for water chemistry testing. If the water chemistry meets original design requirements (Cl ions < 500 ppm, SO_4 ions < 1500 ppm,), no further action is necessary.

3. If the water chemistry tests conclude that it is plausible that these concrete components are being degraded by chemical agents, the levels of chemical concentration will need to be assessed to determine the

appropriate corrective actions. Additional investigate programs may be required.

BASIS: Because of the design and construction of the concrete Auxiliary Building, and the knowledge of the water chemistry during the design of the plant (See Specification 6750-C-33), it is unlikely that chemical attack to concrete is a major concern.

ATTRIBUTES IN NEW PROGRAM (continued)

REVISION: 2 DATE: May 1996

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: Caulking and Sealants, Expansion Joints

AGING MECHANISM: Weathering

APPLICABLE APPENDIX: Appendix O

BACKGROUND: The intended functions of caulking and sealants and expansion joints in the Auxiliary Building are to provide shelter and protection to safety related equipment (including HELB and radiation protection) inside the Auxiliary Building. The caulking and sealants have an additional intended function to provide a flood protective barrier for internal flooding events. The caulking and sealants and expansion joints are components which are typically replaced on condition. However inspections in the plant revealed that an inspection program was required to adequately manage the aging of these components.

Note: The caulking and sealants and expansion joints which require a new program to manage their aging do not perform the intended function of a fire barrier. Caulking and sealants and expansion joints which perform a fire barrier function are managed under an existing program.

RECOMMENDED ATTRIBUTES: The management program for the caulking and sealants and expansion joints is recommended to be developed in association with the resolution to Issue Report IR1995-01698. The program must manage the aging of the caulking and sealants and expansion joints in the Auxiliary Building which support intended functions of the structure. The recommended approaches are:

1. Identify all non-Appendix R caulking and sealants and expansion joint locations that support the structure's intended functions.

2. Develop an inspection and maintenance program which will identify degradation and ensure corrective action is taken before the component

loses the ability to perform its intended function. The program should concentrate on caulking and sealants and expansion joints located in exterior walls and in interior walls and floors where HELB and flooding functions are performed.

BASIS: The management program for the caulking and sealants and expansion joints is recommended to be developed in association with the resolution to Issue Report IR1995-01698. The issue report identified joints in the Auxiliary Building which showed signs of degradation. Resolution of this issue report will ensure development of an aging management program for caulking and sealants and expansion joints in the Auxiliary Building such that these components will be able to perform their intended functions both during the current license period and the period of extended operations.

Attachment 8

ATTRIBUTES IN NEW PROGRAM (continued)

REVISION: 2 DATE: May 1996

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Auxiliary Building

STRUCTURAL COMPONENT DESCRIPTION: Non-accessible structural steel

AGING MECHANISM: Corrosion of Steel

APPLICABLE APPENDIX: Appendix K

BACKGROUND: The intended functions of the Auxiliary Building steel structures is to provide support, protection, and shelter to safety related and non-safety related equipment inside the Auxiliary Building. Corrosion of steel is plausible only if their coatings are degraded and if they are exposed to an aggressive environment and on a continual basis. Aging management of degraded coating conditions on accessible structural steel in the Auxiliary Building is accomplished through the combination of existing plant programs. However, structural steel components not readily accessible require additional aging management.

RECOMMENDED ATTRIBUTES: An age related degradation inspection (ARDI) program as described in the BGE Integrated Plant Assessment Methodology should be implemented to address corrosion of non-accessible structural steel components which support the intended functions of the Auxiliary Building. The ARDI program must consist of the following:

1. Identification of non-accessible locations.
2. Selection of representative structural steel components for inspection.
3. Development of an inspection sample size.
4. Use of Appropriate inspection techniques.
5. Requirements for reporting of results and corrective actions if aging concerns are identified.

Attachment 8

BASIS: The ARDI Program will ensure that degraded conditions due to corrosion of steel are identified and corrected such that non-accessible structural steel components of the Auxiliary Building will be capable of performing their intended functions under all design conditions required by the current licensing basis.

APPENDIX A - FREEZE-THAW

1.0 MECHANISM DESCRIPTION [1]

Repeated cycles of freezing and thawing can alter both the mechanical properties and physical form of the concrete, thus affecting the structural integrity of the component. The freeze-thaw phenomenon occurs when water freezes within the concrete's pores, creating hydraulic pressure. This pressure either increases the size of the cavity or forces water out of the cavity into surrounding voids.

Freeze-thaw damage is characterized by scaling, cracking, and spalling. Scaling or surface flaking occurs in the presence of moisture and is aggravated by the use of deicing salts. Cracks or spalling occurs when voids are already filled with water, and freezing causes pressure to increase. In extreme cases of freeze-thaw damage, the cover over reinforcing steel is reduced, and the reinforcing steel is eventually exposed to accelerated corrosion. Concrete is vulnerable to the expansive effects of the resulting corrosion products, thereby weakening the concrete's resistance to further attack by aggressive environments.

To minimize the adverse effects of freeze-thaw, three factors must be considered in the design and placement of concrete: [2]

- The cement paste must have an entrained air system with an appropriate void spacing factor.
- The aggregate must be of a sufficiently high quality to resist scaling.
- The in-place concrete must be allowed to mature sufficiently before exposure to cyclic freezing and thawing.

As shown in Figure A-1, the optimal air content range extends from 3 to 6 percent based on the nominal maximum size of coarse aggregate. [3]

2.0 EVALUATION

2.1 Conditions

According to Specification ASTM C33-82, "Standard Specification for Concrete Aggregates,"[4] the CCNPP site is located in the geographic region subject to *severe* weathering conditions. As stated in CCNPP's "Civil and Structural Design Criteria,"[5] the frost penetration depth is 20 to 22 inches.

2.2 **Potential Aging Mechanism Determination**

Freeze-thaw is a potential aging mechanism for the following concrete structural components of the Auxiliary Building because they are exposed to outside cold weather:

- Concrete walls above the frost line (which is 2 feet below grade) — LR functions LR-S-1, 2, 4, 5, 6, 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

Other concrete structural components are either below the frost line or are located inside the Auxiliary Building. (Note: The concrete roof of the Auxiliary Building is protected by a built-up roofing system and portions of the Auxiliary Building walls are protected with siding). Therefore, freeze-thaw is not a potential aging mechanism for all other structural components.

2.3 **Impact on Intended Functions**

If the effects of freeze-thaw were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all the intended LR functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

CCNPP concrete design specification No. 6750-C-9[6] specifies:

> *9.3.1 The Portland cement concrete furnished, unless otherwise specified herein, shall conform to ASTM C-94 Specification for Ready Mix Concrete, ACI 318-63 Building Code Requirements for Reinforced Concrete, ACI 301-66 Standard Specifications for Structural Concrete for Building, and ACI Manual of Concrete Inspection.*
>
> *10.1.2.2 All aggregate shall conform to ASTM Designation C33.*

Section 10.1.16 of ASTM Designation C33-67 specifies that:

> *Procedures for making freezing and thawing tests of concrete are described in ASTM Method C290, "Test for Resistance of Concrete Specimens to Rapid Freezing and Thawing in Water," and in ASTM Method C291, "Resistance of Concrete Specimens to Rapid Freezing in Air and Thawing in Water."*

Both ASTM Methods C290 and C291 cover the method for determining the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing in the laboratory.

Design specification No. 6750-C-9 for CCNPP also specifies:

> *10.4.2.1 The Subcontractor shall specify the air entraining agent he proposes to use. It shall be in accordance with ASTM C-260, capable of entraining 3-5% air, be completely water soluble, and be completely dissolved when it enters the batch. The Subcontractor shall give 30 days advance notice of the type of AEA he proposes to use.*

ACI 318[7] and its relevant ACI standards and ASTM specifications provide the physical property requirements of aggregate and air-entraining admixtures, chemical and physical requirements of air-entraining cements, and proportioning of concrete including containing entrained air to maximize the concrete resistance to freeze-thaw action.

2.5 Plausibility Determination

Based on the discussion on Section 2.4, concrete used for the walls of the Auxiliary Building wall were designed and constructed in accordance with the requirements specified in ACI-318 and its relevant ACI standards and ASTM specifications. Those requirements satisfy the attributes discussed in Section 1.0 that maximize concrete's resistance to freeze-thaw action. A walkdown of the Unit 1 containment (located adjacent to the Auxiliary Building and using the same concrete specification) conducted during 1992[8], documented no evidence of damage from freeze-thaw. Additionally, a walkdown in 1994[9] observed no traces of freeze-thaw damage on the exposed exterior walls of the Unit-2 Auxiliary Building. Therefore, freeze-thaw is not a plausible aging mechanism for the walls of the Auxiliary Building.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair freeze-thaw damage. Since freeze-thaw is not a plausible aging mechanism that could degrade the Auxiliary Building structural components, no management program is necessary.

3.0 CONCLUSION

The CCNPP site is located in the geographic region subject to *severe* weathering conditions. Although freeze-thaw cycles can degrade concrete components that are exposed to cold temperatures and in constant contact with moisture, the Auxiliary Building walls were constructed with concrete designed to maximize its resistance to freeze-thaw cycles. A walkdown inspection of the Unit 1 containment structure performed in 1992 found no indication of freeze-thaw effect on the concrete structure. Additionally, a walkdown inspection of the exterior walls of the Unit 2 Auxiliary Building in 1994[9] found no indication of freeze-thaw damage. Since the Auxiliary Building is adjacent to the containment and fabricated using the same concrete specification, these findings substantiated further the conclusion that freeze-thaw is not a plausible aging mechanism for the structural components of the Auxiliary Building.

4.0 RECOMMENDATION

Freeze-thaw is not a plausible aging mechanism for any concrete structural components of the Auxiliary Building. No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. Mather, B., "How to Make Concrete that Will Be Immune to the Effects of Freezing and Thawing," ACI Fall Convention, San Diego, November 1989.

3. Troxell, G. E., Davis, H. E., and Kelly, J. W., *Composition and Properties of Concrete*, Second Edition, McGraw-Hill, 1968.

4. "Standard Specification for Concrete Aggregates," American Society of Testing and Materials, ASTM C33-82.

5. Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2, by Bechtel Power Corporation, Revision 0, August 2, 1991.

6. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

7. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

8. " Examination of the Unit 1 Containment Structure - Calvert Cliffs Nuclear Power Plant," August 1992.

9. Walkdown - Auxiliary Building, November, 1994.

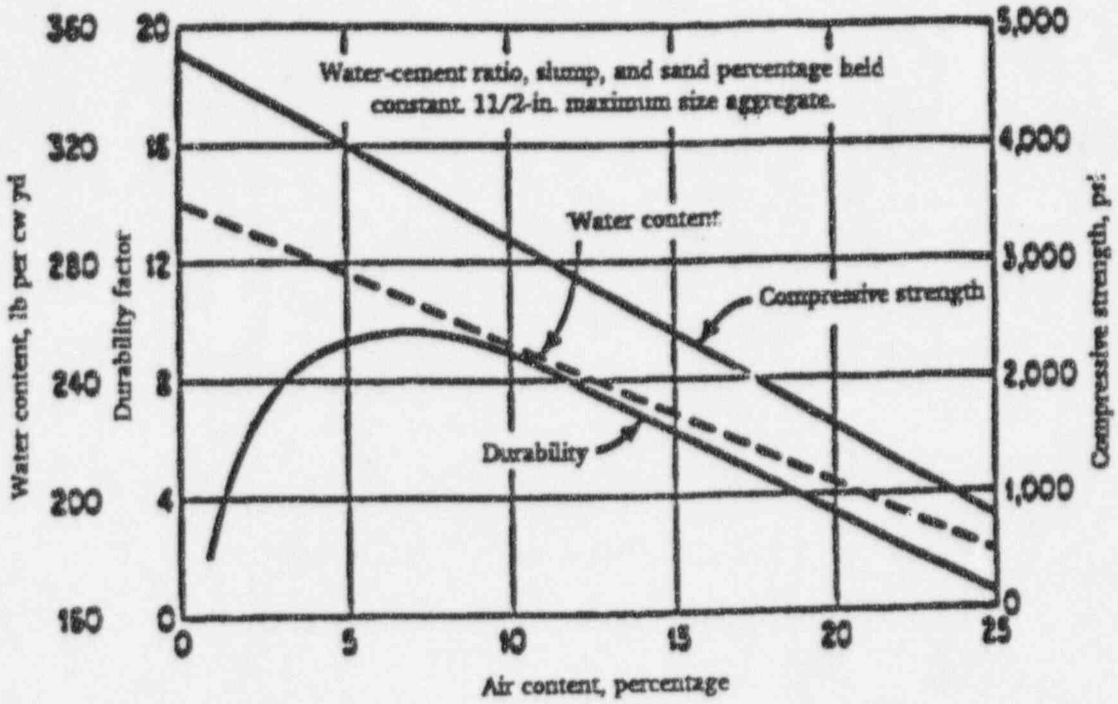

Figure A-1

Effects of Air Content
on Durability, Compressive Strength, and
Required Water Content of Concrete
(Source: Reference 3)

APPENDIX B - LEACHING OF CALCIUM HYDROXIDE

1.0 MECHANISM DESCRIPTION[1]

Water, either from rain or melting snow, that contains small amounts of calcium ions can readily dissolve calcium compounds in concrete when it passes through cracks, inadequately prepared construction joints, or areas inadequately consolidated during placing. The most readily soluble calcium compound is calcium hydroxide (lime). The aggressiveness or affinity of water to leach calcium hydroxide depends on its dissolved salt content and its temperature. Since leaching occurs when water passes through the concrete, structures that are subject to flowing liquid, ponding, or hydraulic pressure are more susceptible to degradation by leaching than those structures that water merely passes over. Leaching of calcium hydroxide is visible on concrete surfaces that have dried. The leachate is almost colorless until carbon dioxide is absorbed and the material dries as a white deposit. The white deposit is a product of water, free lime from the concrete, and carbon dioxide that has been absorbed from the air.

When calcium hydroxide is leached away, other cementitious constituents become exposed to chemical decomposition, eventually leaving behind silica and alumina gels with little or no strength.[2] Leaching over a long period of time increases the porosity and permeability of concrete, making it more susceptible to other forms of aggressive attack and reducing the strength of concrete. Leaching also lowers the pH of concrete and threatens the integrity of the exterior protective oxide film of rebar.

Resistance to leaching and efflorescence can be enhanced by using concrete with low permeability. A dense concrete with a suitable cement content that has been well cured is less susceptible to calcium hydroxide loss from percolating water because of its low permeability and low absorption rate. The design attributes to enhance water-tightness include low water-to-cement ratio, smaller coarse aggregate, long curing periods, entrained air, and thorough consolidation.[3] Figures B-1 and B-2 show the impact on permeability due to water-to-cement ratio, aggregate size, and curing time.

2.0 EVALUATION

2.1 Conditions

The exterior walls of the Auxiliary Building not protected by siding are exposed to the outside environment and are expected to have rainwater passing over the surface. The Auxiliary Building concrete roof is provided with a built-up roofing system with a drainage system to prevent ponding and, therefore, does not pose a threat to Leaching of Calcium Hydroxide. The Auxiliary Building foundation (concrete mat) is in contact with underground water. A permanent dewatering system was installed during construction to maintain a stable groundwater table at El. 10'-0", which is the above the elevation of the Auxiliary Building foundation mat (top of mat elevation varies from El. +3'-0" to El. -15'-0").

2.2 Potential Aging Mechanism Determination

Leaching of calcium hydroxide is a potential aging mechanism for the following structural components of the Auxiliary Building because they could be exposed to flowing liquid, ponding, or hydraulic pressure:

- Exterior Concrete Walls — LR functions LR-S-1, 2, 4, 5, 6, 7
- Concrete Foundation Mat — LR functions LR-S-1, 5

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

Leaching of calcium hydroxide is not a potential aging mechanism for other structural components of the Auxiliary Building because they are inside the Auxiliary Building. Additionally, the concrete roof slabs are protected by a built-up roofing system with its own drainage system and portions of the exterior concrete walls are protected by siding.

2.3 Impact on Intended Functions

If the effects of leaching of calcium hydroxide were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

Leaching attack can be minimized by providing a low-permeability concrete mix design during construction. CCNPP concrete design specification No. 6750-C-9[4] specifies:

9.3.1 The Portland cement concrete furnished, unless otherwise specified herein, shall conform to ASTM C-94 Specification for Ready Mix Concrete, ACI 318-63 Building Code Requirements for Reinforced Concrete, ACI 301-66 Standard Specifications for Structural Concrete for Building, and ACI Manual of Concrete Inspection.

12.1 Concrete Quality

12.1.1.1 Portland cement shall conform to ASTM Designation C-94-67, Alternate No. 1 and ACI 301-66.

12.1.2.1 Concrete shall meet the following requirements:

Class	28-Day Strength (psi)	Nominal Slump at Point of Placement (in.)	Slump Tolerance (in.)	Maximum Aggregate Size	Use and Location
B-1	3,000	3	± ½	3/4 in.	Structural Concrete Wall & Slabs less than 12" thick & Congested Rebar
B-2	3,000	3	± ½	1-1/2 in.	Turbine Pedestal & other Structural Concrete
B Grout	3,000	-	-	#4	Construction Joints
C-1	4,000	3	± ½	3/4 in.	Walls & Slabs less than 12" thick & Congested Rebar
C-2	4,000	2	± ½	1-½ in.	Containment Base Slab and Other Structural Concrete
C Grout	4,000	–	–	#4	Construction Joints
Dry Pack	4,000	0	–	#4	As Directed
Tremie Concrete	4,000	6	–	3/4 in.	As Directed

12.1.5 Mix Design

12.1.5.1 The Constructor shall retain an approved Testing Laboratory, at his own cost, to design and test initial concrete mixes. The initial mixes shall be designed in accordance with ACI Standards 613 and 301 to produce a required strength of 15 percent over specified strength for reinforced concrete at 28 days and 25 percent over specified strength for post-tensioned concrete at 28 days for each class of concrete with slump and maximum sizes of aggregate as specified in the Classification Table (Section 12.1.2).

> *12.1.5.2 The Constructor shall furnish the Subcontractor with mix designs one month prior to the manufacture of concrete. Furnishing mix designs shall not relieve the Subcontractor of his responsibility for compliance with the provisions of the Specification. Where necessary, the Constructor shall increase or decrease cement factors as deemed necessary for design mixes using statistical methods described in the ACI 214-65 for the particular class of concrete. An increase in the water-cement ratio of a mix design or a decrease in its cement quantity shall constitute a new mix design and the provisions of Section 12.1.5.1 of this Specification shall apply. Calcium chloride shall not be used.*

2.5 Plausibility Determination

Based on the discussion in Section 2.1, the Auxiliary Building exterior walls and foundation mat are exposed to water passing over the surface. The Auxiliary Building foundation mat is located below the designed underground water table and may be subjected to some hydraulic pressure. However, as discussed in Section 2.4, concrete used for the Auxiliary Building was designed in accordance with ACI 318[5] and its relevant ACI standards and ASTM specifications to maximize resistance to leaching of calcium hydroxide. A walkdown[6] in 1992 observed only slight traces of leaching on the containment dome and wall and were judged to have no adverse impact on the integrity of these components. Since the Auxiliary Building is adjacent to the containment and is fabricated from the same concrete specification, this is a good indication that the Auxiliary Building exterior walls and foundation mat also have had no adverse impact on their integrity, due to leaching of calcium hydroxides. Additionally, a walkdown in 1994[8] observed no traces of leaching on the exposed exterior walls of the Unit-2 Auxiliary Building. Therefore, leaching of calcium hydroxide is not a plausible aging mechanism for the Auxiliary Building exterior walls or foundation mat.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage to concrete due to leaching of calcium hydroxide. Since leaching of calcium hydroxide is not a plausible aging mechanism that could degrade the Auxiliary Building structural components, no management program is necessary.

3.0 CONCLUSION

The Auxiliary Building foundation mat and a portion of the exterior walls (those not covered by protective siding) are exposed to water, however, no ponding or hydraulic pressure will form to leach the calcium hydroxide. Although the Auxiliary Building foundation mat could be subjected to hydraulic pressure due to underground water, the concrete mix was designed for low permeability and high compressive strength which provide the best protection against leaching.

This conclusion is supported by a 1992 walkdown inspection[6] during which only minor traces of leaching marks were detected in various areas of the containment dome and wall. These indications were judged to have no impact on containment integrity during the 10S evaluation of the containment structural components (Note: The Auxiliary Building is immediately adjacent to the containment and is fabricated using the same concrete specification). Additionally, a walkdown in 1994[8] observed no traces of leaching on the exposed exterior walls of the Unit-2 Auxiliary Building. Therefore, leaching of calcium hydroxide is not a plausible aging mechanism for any concrete structural components of the Auxiliary Building.

4.0 RECOMMENDATION

Leaching of calcium hydroxide is not a plausible aging mechanism for any concrete structural components of the Auxiliary Building. No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. Troxell, G. E., Davis, H. E., and Kelly, J. W., *Composition and Properties of Concrete*, Second Edition, McGraw Hill, 1968.

3. "Guide to Durable Concrete," American Concrete Institute, ACI-201.2R-67.

4. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

5. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

6. "Examination of the Unit 1 Containment Structure - Calvert Cliffs Nuclear Power Plant," August 1992.

7. *Concrete Manual*, Eighth Edition, U.S. Department of the Interior, 1975.

8. Walkdown - Auxiliary Building, November, 1994.

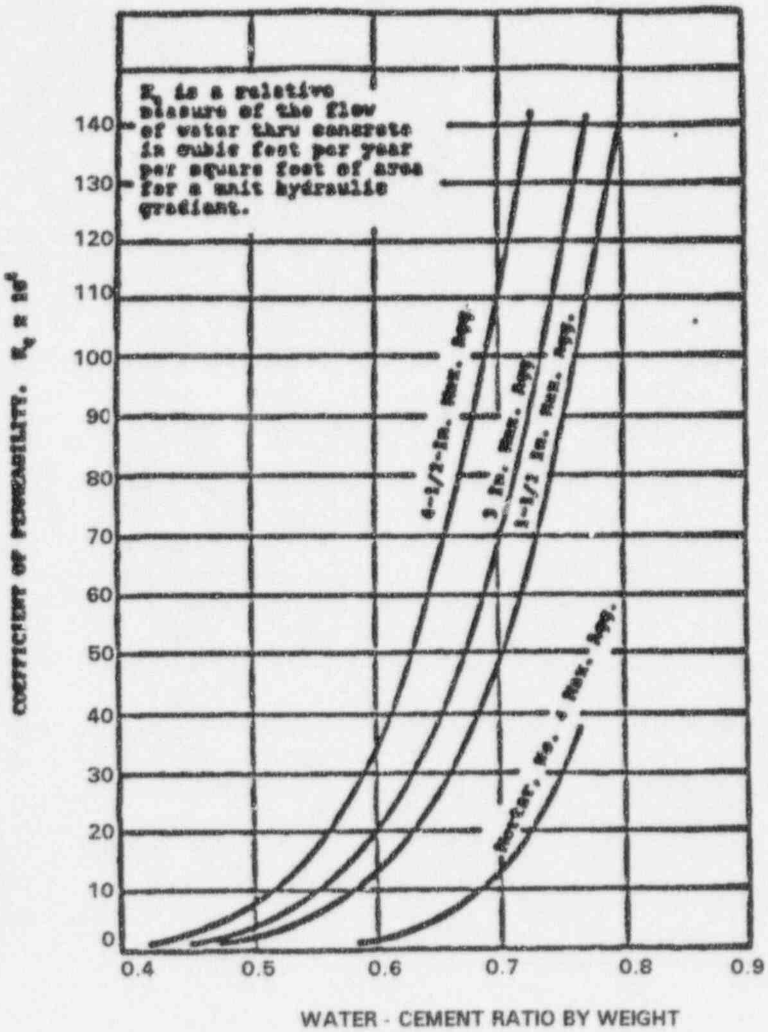

Figure B-1

Relationship Between Coefficient of Permeability and Water-to-Cement Ratio (Source: Reference 7)

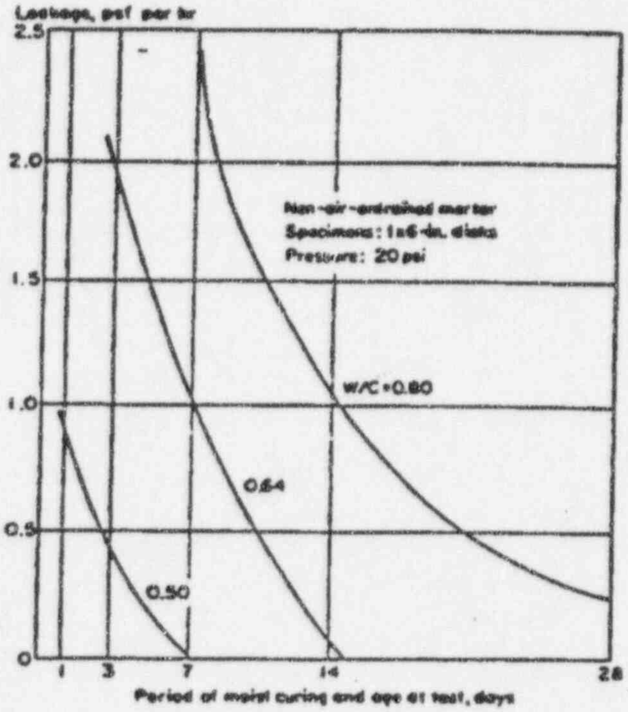

Figure B-2

Effects of Curing Period on Permeability
(Source: Reference 2)

APPENDIX C - AGGRESSIVE CHEMICALS

1.0 MECHANISM DESCRIPTION[1]

Concrete, being highly alkaline (pH > 12.5), is vulnerable to degradation by strong acids. Acid attack can increase porosity and permeability of concrete, reduce its alkaline nature at the surface of the attack, reduce strength, and render the concrete subject to further deterioration. Portland cement concrete is not acid-resistant, although varying degrees of resistance can be achieved depending on the materials used and the attention to placing, consolidating, and curing. No Portland cement concrete, regardless of its composition, will withstand exposure to highly acidic fluids for long periods.

Below grade, sulfate solutions of sodium, potassium, and magnesium sometimes found in groundwater may attack concrete, often in combination with chlorides. The exposed surfaces of structures located near industrial plants are vulnerable to industrial pollution from the sulfur-based acid rain and are subject to deterioration. Sulfate attack produces significant expansive stresses within the concrete, leading to cracking, spalling, and strength loss. Once established, these conditions allow further exposure to aggressive chemicals. Groundwater chemicals can also damage foundation concrete. A dense concrete with low permeability may provide an acceptable degree of protection against mild acid attack. Any factors that tend to improve the compressive strength of the concrete will have a beneficial effect on low permeability. Therefore, the better the quality of the constituent material, the less permeable the concrete. Low water-to-cement ratio, smaller aggregate, long curing period, entrained air, and thorough consolidation all contribute to watertightness.

Concrete thus constructed has a low permeability and effective protection against sulfate and chloride attack. Minimum degradation threshold limits for concrete have been established at 500 ppm chloride or 1,500 ppm sulfates. The use of an appropriate cement type (e.g., ASTM C150, Type II) and pozzolan (e.g., fly ash) also increases sulfate resistance.

2.0 EVALUATION

2.1 Conditions

The only significant inventory of aggressive chemicals stored inside the Auxiliary Building is borated water, and it is primarily in safety-related systems such as the chemical volume control system. Because of the safety significance of these systems, undetected leakages of borated water for an extended period of time cannot occur. Additionally, the borated water is stored in tanks located in the Protected Area of the Auxiliary Building, which means that Health Physics technicians are on duty in these areas 24 hours a day. Therefore, the Auxiliary Building's interior surface and all internal structural components are not exposed to the risk of aggressive chemicals.

There is no heavy industry near the CCNPP site that could release aggressive chemicals to the atmosphere. However the above-grade portion of the Auxiliary Building exterior walls are exposed to an environment containing chloride ions due to the Auxiliary Building's proximity to the Chesapeake Bay.

The outside, below-grade surface of the Auxiliary Building foundation mat and walls are exposed to soil and groundwater. The potential for degradation by aggressive chemicals depends on the quality of concrete and the chemical composition of the groundwater. Although a waterproof membrane was installed against the external surfaces of the concrete during construction[6], the minimum life expectancy of the membrane is only five years.

2.2 Potential Aging Mechanism Determination

Attack by aggressive chemicals is a potential aging mechanism for the following concrete structural components of Auxiliary Building because they are exposed to outside environment:

- Exterior concrete walls — LR functions LR-S-1, 2, 4, 5, 6, 7
- Concrete foundation mat — LR functions LR-S-1, 5

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

Other concrete structural components are located inside the Auxiliary Building; therefore, attack by aggressive chemicals is not a potential aging mechanism. Additionally, the concrete roof slabs are protected by a built-up roofing system with its own drainage system and a portion of the exterior concrete walls are protected by siding.

2.3 Impact on Intended Functions

If the effects of attack by aggressive chemicals were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

The Auxiliary Building was constructed with concrete that complies with CCNPP's design specification No. 6750-C-9[2] to assure low permeability.

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, attack by aggressive chemicals is not a plausible aging mechanism for the Auxiliary Building exterior walls above grade. Additionally, a walkdown in 1994[4] observed no traces of aggressive chemical damage on the exposed exterior walls of the Unit-2 Auxiliary Building.

Because chemical contents of groundwater are not known, attack by aggressive chemicals to the below-grade portion of the Auxiliary Building exterior concrete walls and mat is a plausible aging mechanism.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage to concrete due to aggressive chemicals. Since attack by aggressive chemicals is not a plausible aging mechanism for all concrete components inside the Auxiliary Building and the Auxiliary Building exterior walls above grade, no management program is needed for these components.

3.0 CONCLUSION

Attack by aggressive chemicals is not plausible for the Auxiliary Building exterior walls above grade because concrete with low permeability, which minimizes concrete cracking, was used in construction of the Auxiliary Building walls. Additionally, there is no heavy industry near the CCNPP site to release aggressive chemicals. Attack by aggressive chemicals is also not plausible for concrete components inside the Auxiliary Building because excessive leakages of stored aggressive chemicals inside the Auxiliary Building cannot occur.

The below-grade portion of the Auxiliary Building and the foundation mat are exposed to groundwater. Because the quality of groundwater is not known, degradation due to aggressive chemicals is plausible.

4.0 RECOMMENDATION

During initial plant construction, groundwater observation wells were installed to monitor the fluctuation of the groundwater table, and samples were taken for groundwater quality testing.[3] These wells have been taken out of service, however, several piezometers in the area of the Auxiliary Building are still in place[5]. It is recommended that a program be developed to investigate the groundwater chemistry using the existing piezometers. This data can be used to determine if it is plausible that aggressive chemicals have degraded the exterior surface of the Auxiliary Building structure below grade.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

3. "Specification for Furnishing and Installation of Piezometers - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-23E, Revision 0, November 1973.

4. Walkdown - Auxiliary Building, November, 1994.

5. Drawing 61-523-E, Sheet 1, "Yard Piping Plan - Sheet 1", Rev. 27.

6. "Specification for Furnishing and Delivering Waterproof Membrane - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-33, Revision 0, December 1968.

APPENDIX D - REACTIONS WITH AGGREGATES

1.0 MECHANISM DESCRIPTION[1]

Certain mineral constituents of all aggregates react with chemical compounds that compose the Portland cement, most notably alkalis. Alkalis may also be introduced from admixtures, salt-contaminated aggregates, and penetration by seawater or solutions of deicing salt. However, it is only when the expansive reaction products become extensive and cause cracking of concrete that aggregate reactivity is considered a deleterious reaction.

Three principal deleterious reactions between aggregates and alkalis have been identified as alkali-aggregate, cement-aggregate, and expansive alkali-carbonate reactions.

Alkali-aggregate reaction, more properly designated as alkali-silica reaction, involves aggregates that contain silica and alkaline solutions. All silica minerals have the potential to react with alkaline solution, but the degree of reaction and ultimate damage incurred can vary significantly. Alkali-silica reaction can cause expansion and severe cracking of concrete structures. Reactive materials in the presence of potassium, sodium, and calcium oxides derived from the cement react to form solids, which can expand upon exposure to water.

Cement-aggregate reaction occurs when the alkalis in cement and some siliceous constituents of the aggregates react. This reaction is complicated by environmental conditions that produce high concrete shrinkage and alkali concentrations on the surface due to drying. Sand-gravel aggregates from some river systems in the Midwestern United States have been involved in deteriorated concrete attributable to this reaction.

Expansive alkali-carbonate reaction occurs between certain carbonate aggregates and alkalis, and produces expansion and cracking. Certain limestone aggregates, usually dolomitic, have been reported as reactive.

Aggregates that react with alkalis can cause expansion of varying severity, even to the extent of producing cracking of the concrete and resulting loss of strength and durability if the expansion is severe. The cracking is irregular and has been referred to as *map cracking*.

Moisture must be available for chemical reactions between aggregates and alkalis to occur. Consequently, areas that are either consistently wet or alternately wet and dry are susceptible to deterioration given the presence of potentially reactive aggregates.

The deleterious effects of reactive aggregates are best avoided by using aggregates from sources that have a proven record of service. If such records are unavailable, aggregates should be examined petrographically to identify potentially reactive constituents. Chemical reactions of aggregates for both fast and slow reaction rates were recognized as early as 1940. The method to identify the reactive constituents in concrete aggregates was first published in ASTM C-289, "Potential Reactivity of Aggregates (Chemical Method)"[2] and ASTM C-295, "Petrographic Examination of Aggregates for Concrete"[3] in 1952 and 1954, respectively. Both standards provide guidance for selecting aggregates and cements to avoid alkali-aggregate reactions.

2.0 EVALUATION

2.1 Conditions

The aggregates used in the concrete of the CCNPP Auxiliary Building came from sites in Charles County, Maryland[4], which is not in the geographic regions known to yield aggregates suspected of or known to cause aggregate reaction.

2.2 Potential Aging Mechanism Determination

Reaction with aggregates is a potential aging mechanism for the following concrete structural components if reactive aggregates were used in the concrete structure construction:

- Concrete columns — LR functions LR-S-1, 5
- Concrete beams — LR functions LR-S-1, 5
- Ground floor slab and equipment pads — LR functions LR-S-1, 5
- Elevated floor slabs — LR functions LR-S-1, 2, 5, 7
- Roof Slabs — LR functions LR-S-2, 4

•	Concrete walls	LR functions LR-S-1, 2, 4, 5, 6, 7
•	Concrete foundation mat	LR functions LR-S-1, 5
•	Fluid retaining walls & slabs	LR functions LR-S-1

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If the effects of reaction with aggregates were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

All aggregates used in construction of the CCNPP Auxiliary Building structure were investigated, tested, and examined based on the following specifications:

CCNPP's design specification No. 6750-C-9[5] specifies:

> *10.1.1.1 Cement shall be Portland cement, Type II conforming to ASTM Designation C-150, . . . The cement shall not contain more than 0.60 percent by weight of alkalies calculated as Na_2O plus 0.658 K_2O. Only one brand of cement shall be used for all work. . . .*
>
> *15.2.3.1 The Bidder, at his expense, shall retain an approved independent testing laboratory to sample and test aggregates and the aggregate source in accordance with methods as specified in ASTM Designation C-33. Acceptability of aggregate and source shall be based on the following ASTM tests:*

Method of Test	*ASTM Designation*
. . .	. . .
Potential Reactivity	*C-289*

> *15.2.3.4 Upon award of the subcontract, the Subcontractor shall submit for petrographic analysis, in accordance with ASTM Designation C-295, a 5-pound sample of quarried material, or if alluvial, 2-1/2 pounds each of sand and coarse material which has been certified as sampled at the proposed aggregate source by an approved testing laboratory.*
>
> *15.2.3.6 . . . Aggregates will be tested during the progress of the work. . . .The following user tests will be performed on every 4,000 tons of aggregates delivered to the jobsite:*

Method of Test	*ASTM Designation*
...	...
Potential Reactivity	*C-289*

Both ASTM C289 and C295 provide guidance for selecting aggregates and cements to avoid alkali-aggregate reactions, and both standards were specified for use in CCNPP's concrete specification. The aggregates used in the Auxiliary Building concrete were specifically investigated, tested, and examined in accordance with the ASTM specifications to determine potential for reactivity with alkalis.

2.5 Plausibility Determination

Based on the discussion in Section 2.4, the aggregates used in CCNPP's Auxiliary Building concrete were specifically investigated, tested, and examined in accordance with the pertinent ASTM specifications to minimize the potential for reactivity with alkalis. This conclusion is supported by a 1992 containment walkdown inspection report[6] that documented no indications of concrete damage due to this mechanism. It is noted that the Auxiliary Building is immediately adjacent to the containment structure and was fabricated using the same 6750-C-9 specification. Additionally, a walkdown in 1994[7] observed no traces of map cracking on the exposed exterior walls of the Unit-2 Auxiliary Building. For these reasons, reactions with aggregates will not degrade any concrete components of the Auxiliary Building and will have no adverse impact on the intended functions of these concrete structural components. Therefore, reaction with aggregates is not a plausible aging mechanism for any concrete structural components of the CCNPP Auxiliary Building.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage incurred by reaction with aggregates. Since reaction with aggregates is not a plausible aging mechanism that could degrade the Auxiliary Building structural components, no management program is necessary.

3.0 CONCLUSION

Since the potential effects of aggregate reactions on all concrete components were well known and understood, measures to avoid using reactive aggregates were implemented for CCNPP in design specification No. 6750-C-9. The aggregates used in the Auxiliary Building concrete were specifically investigated, tested, and examined in accordance with applicable ASTM specifications to minimize any reactivity of aggregates with alkalis.

4.0 RECOMMENDATION

Reaction with aggregates is not a plausible aging mechanism for any concrete component of the CCNPP Auxiliary Building and requires no further evaluation or recommendation.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Potential Reactivity of Aggregates (Chemical Method)," American Society of Testing and Materials, ASTM C-289-66.

3. "Petrographic Examination of Aggregates for Concrete," American Society of Testing and Materials, ASTM C-295-65.

4. Letter from Charles County Sand & Gravel Co., Inc. to Bechtel Corporation, June 30, 1972.

5. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and No. 2," Design Specification No. 6750-C-9, Revision 8, April 1970.

6. "Examination of the Unit 1 Containment Structure - Calvert Cliffs Nuclear Power Plant," August 1992.

7. Walkdown - Auxiliary Building, November, 1994.

APPENDIX E - CORROSION OF EMBEDDED STEEL/REBAR

1.0 MECHANISM DESCRIPTION[1]

The environments that induce corrosion of reinforcing steel, embedded steel, and cast-in-place anchor bolts are similar. Therefore, this appendix is applicable to all structural components that are either part of or comprise these three component types.

Concrete's high alkalinity (pH > 12.5) provides an environment around embedded steel/rebar and protects them from corrosion. If the pH is lowered (e.g., to 10 or less), corrosion may occur. However, the corrosion rate is still insignificant until a pH of 4.0 is reached. A reduction in pH can be caused by the leaching of alkaline products through cracks, the entry of acidic materials, or carbonation. Chlorides can be present in constituent materials of the original concrete mix (i.e., cement, aggregates, admixtures, and water), or they may be introduced environmentally. The severity of corrosion is influenced by the properties and type of cement and aggregates as well as the concrete moisture content.

Galvanized decking and galvanized embedments are used in some structures. Since galvanizing material is not considered a dissimilar metal, its application will not aggravate corrosion of the structure.

Studies have also been conducted to determine the effects of stray electrical currents on reinforcing steel. Lightning conductors exchange electrons with the atmosphere and, if connected to reinforcing steel, may accelerate the corrosion process. However, while stray electrical currents can aggravate active corrosion, they are not age-related[2].

Corrosion products have a volume greater than the original metal. The presence of corrosion products on embedded steel or rebar subjects the concrete to tensile stress that eventually causes hairline cracking, rust staining, spalling, and more severe cracking. These actions will expose more embedded steel/rebar to a potentially corrosive environment and cause further deterioration in the concrete. A loss of bond between the concrete and embedded steel/rebar will eventually occur, along with a reduction in steel cross section. Rebar corrosion can cause deterioration of concrete from a series of hairline cracking, rust staining, spalling, and more severe cracking. These conditions can ultimately impair structural integrity.

The degree to which concrete will provide satisfactory protection for embedded steel/rebar depends in most instances on the quality of the concrete and the depth of concrete cover over the steel. The permeability of the concrete is also a major factor affecting corrosion resistance. Concrete of low permeability contains less water under a given exposure and, hence, is more likely to have lower electrical conductivity and better resistance to corrosion. Such concrete also resists absorption of salts and their penetration into the embedded steel and provides a barrier to oxygen, an essential element of the corrosion process. Low water-to-cement ratios and adequate air entrainment increase resistance to water penetration and thereby provide greater resistance to corrosion.

2.0 EVALUATION

At CCNPP, embedded steel has been used in composite structural members or as anchorages of concrete surface attachments. Liner plate anchorages, either steel studs or structural shapes, used in the spent fuel pool are also considered as embedded steel. Reinforcing steel (rebar) and cast-in-place anchors are both treated as embedded steel in the evaluation of corrosion effects, because the environment and the technical basis for their corrosion induction are similar. The base plates under the columns or those used as part of attachments to the concrete surface are treated as structural steel, and the evaluation of their corrosion effects is addressed in Appendix K. Because the design and inspection requirements of liner plates differ significantly from those of structural steel, the corrosion effect on liner plates is discussed separately in Appendix L.

2.1 Conditions

The only significant inventory of aggressive chemicals stored inside the Auxiliary Building is borated water, and it is primarily in safety related systems such as the chemical volume control system. Because of the safety significance of these systems, undetected leakages of borated water for an extended period of time cannot occur. Therefore, the Auxiliary Building's interior surface and all internal structural components are not exposed to the risk of aggressive chemicals.

The primary area of concern is the exterior surface of the Auxiliary Building where moisture and oxygen may have access to the embedded steel and rebars. Chlorides in the atmosphere from the Chesapeake Bay could gain access to the steel. However, only above-grade portion of the Auxiliary Building is exposed to this environment. The below-grade exterior surface

could be exposed to groundwater on a more or less continuous basis. A dewatering system, installed during construction[4], would maintain a stable groundwater level at El.+10.0 ft, which is above the elevation of the Auxiliary Building foundation mat. However, there is no known program to determine if the dewatering system continues to perform its function after construction. Additionally, during construction, a waterproof membrane was installed against all external concrete surfaces below the water table[9]. However, the minimum stated life expectancy for the membrane is only five years.

2.2 Potential Aging Mechanism Determination

Corrosion of embedded steel/rebar is a potential aging mechanism for the following structural components of Auxiliary Building because they are exposed to the outside environment and could be subjected to corrosive environments:

- Exterior concrete walls — LR functions LR-S-1, 2, 4, 5, 6, 7
- Concrete foundation mat — LR functions LR-S-1, 5

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading or from adjacent areas of the plant.

Other concrete structural components are located inside the Auxiliary Building; therefore, corrosion of embedded steel/rebar is not a potential aging mechanism.

2.3 Impact on Intended LR Functions

If the effects of corrosion of embedded steel/rebar were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all the intended LR functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

The Auxiliary Building was constructed with concrete that complies with CCNPP's design specification No. 6750-C-9[3], which adheres to the relevant ACI Codes and ASTM specifications for a concrete structure of low permeability. Also proper concrete covers were specified in accordance with ACI 318 Code to effectively prohibit exposure of embedded steel/rebar to the corrosive environment.

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, corrosion is not a plausible aging mechanism for embedded steel/rebar in the above-grade portion of the Auxiliary Building exterior walls, and all components inside the Auxiliary Building. This conclusion is supported by a containment 1992 walkdown inspection report[5] that documented no indications of damage to concrete due to corrosion of embedded steel/rebar. The Auxiliary Building is immediately adjacent to the containment and is fabricated with the same concrete specification. Additionally, a walkdown in 1994[7] observed no traces of damage to concrete due to corrosion of embedded steel/rebar on the exposed exterior walls of the Unit-2 Auxiliary Building.

As discussed in Section 2.1, only the below-grade portion of the exterior walls of the Auxiliary Building and the exterior surface of the Auxiliary Building foundation mat could be exposed to an aggressive environment on a continuous basis and could be susceptible to embedded steel/rebar corrosion. Because the chemical quality of the underground water is not known, corrosion of embedded steel/rebar is a plausible aging mechanism for the below-grade portion of the Auxiliary Building exterior walls and the exterior surface of the Auxiliary Building concrete foundation mat.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage of the concrete structure due to corrosion of embedded steel/rebar.

3.0 CONCLUSION

Based on the discussion in Sections 2.1 and 2.4, corrosion of embedded steel/rebar is not a plausible aging mechanism for concrete components inside the Auxiliary Building and the above-grade portion of the Auxiliary Building exterior walls. No further evaluation is required for these concrete structural components.

Because the quality of the groundwater is not known, corrosion of embedded steel/rebar is a plausible aging mechanism for the below-grade portion of the Auxiliary Building exterior walls and the concrete foundation mat.

4.0 RECOMMENDATION

An evaluation program is recommended for testing the groundwater quality to determine the plausibility of corrosion of embedded steel/rebar in the below- grade portion of the Auxiliary Building (walls and mat). During initial plant construction, groundwater observation wells were installed to monitor the groundwater table, and samples were taken for groundwater quality testing.[6] These wells have been taken out of service. However, several piezometers in the area of the Auxiliary Building are still in place[8]. It is recommended that a program be developed to investigate the groundwater chemistry using the existing piezometers. This data can be used to determine if it is plausible that aggressive chemicals have degraded the exterior surface of the Auxiliary Building structure below grade, which would, in turn, indicate if it is plausible that corrosion of embedded steel or rebar has occurred.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. Skoulikidas, T., Tsakopoulos, A., and Moropoulos, T., "Accelerated Rebar Corrosion When Connected to Lightning Conductors and Protection of Rebars with Needle Diodes Using Atmosphere Electricity," in Publication ASTM STP 906, "Corrosion Effect of Stray Currents and the Techniques for Evaluating Corrosion of Rebars in Concrete."

3. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

4. "Calvert Cliffs Nuclear Power Plant, Units 1 and 2, Updated Final Safety Analysis Report (UFSAR)," Baltimore Gas and Electric Co.

5. "Examination of the Unit 1 Containment Structure - Calvert Cliffs Nuclear Power Plant," August 1992.

6. "Specification for Furnishing and Installation of Piezometers - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-23E, Revision 0, November 1973.

7. Walkdown - Auxiliary Building, November, 1994.

8. Drawing 61-523-E, Sheet 1, "Yard Piping Plan - Sheet 1", Rev. 27.

9. "Specification for Furnishing and Delivering Waterproof Membrane - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-33, Revision 0, December 1968.

APPENDIX F - CREEP

1.0 MECHANISM DESCRIPTION[1]

Creep is defined as the time-dependent increase of strain in hardened concrete that has been subjected to sustained stress. The sustained stress results from the dead load and live load of the structure and from temperature effects. Creep deformation is a function of loading history, environment, and material properties of the concrete. The time-dependent deformation of concrete under compressive load consists of strain resulting from progressive cracking at the aggregate-cement paste interface, from moisture exchange with the atmosphere, and from moisture movement within the concrete.

The effects of temperatures on creep are not linear. At 122 °F, creep strain is about two to three times as great as at room temperature (68 - 75 °F.) But from 122 °F to 212 °F, creep strain continues to increase four to six times that experienced at room temperatures. While little is known about creep rate beyond 212 °F, the maximum creep rate may have occurred between 122 °F and 176 °F.[2]

Creep is not visible because micro-cracking occurs at the aggregate cement-paste interface. The deformation resulting from cracking and from moisture exchange with the atmosphere is not recoverable. Creep deformation can generally be characterized as follows:

- Increased water-to-cement ratio results in increased creep magnitude.
- Increased aggregate-to-cement ratio results in increased creep magnitude for a given volume of concrete.
- Creep deformation is approximately proportional to the applied load for a level not exceeding about 40% to 60% of the ultimate strength of concrete.
- Concrete age at application of load affects creep (i.e., the older the concrete, the less the creep).

- Creep increases with increased temperature.
- Aggregate with a high modulus of elasticity and low porosity will minimize creep.

Creep-induced concrete cracks are typically not large enough to result in concrete deterioration or in exposure of the reinforcing steel to environmental stressors. Cracks of this magnitude do not reduce the concrete's compressive strength. Creep is significant when new concrete is subjected to load and decreases exponentially with time. Any degradation is noticeable in the first few years of plant life. According to ACI 209R-82,[2] 78% of creep occurs within the first year, 93% within 10 years, 95% within 20 years, and 96% within 30 years. At any given stress, high-strength concretes show less creep than low-strength concretes.

ACI 209R-82 provides guidance for predicting creep in concrete structures. Prestressed concrete structures may be subject to more pronounced creep and relaxation effects, particularly in combination with elevated temperatures.

2.0 EVALUATION

2.1 Conditions

There is no condition in CCNPP that could aggravate the effect of concrete creep initiated right after concrete construction. Most of the concrete creep will have occurred well before the time of a license renewal application. Therefore, creep of concrete structural components should not be regarded as an aging mechanism for license renewal.

2.1 Potential Aging Mechanism Determination

Creep is not a potential aging mechanism for any Auxiliary Building concrete structural components because creep proceeds at a decreasing rate with age and is not expected to continue after 40 years.

2.3 Impact on Intended Functions

Since creep is not a potential aging mechanism, it will not affect the intended functions of any Auxiliary Building structural components.

2.4 Design and Construction Considerations

At CCNPP, all reinforced concrete components were designed based on the working stress design method. The induced stresses are much lower than the ultimate strength of the concrete, which is specified as f'_c = 4,000 psi for most of the Auxiliary Building concrete structural components. The Auxiliary Building and its concrete components are subject to low forces (basically only dead load) during normal plant operation condition. Therefore, creep in all concrete components is minimal because of the low compressive stresses in concrete and the use of high-strength concrete. Besides, creep proceeds at a decreasing rate with age; normally, 96 % of creep has occurred within 30 years.[2] Therefore, creep is not expected to continue during the period of extended operation.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Most of the concrete creep will have occurred well before the time of license renewal application. Therefore, creep of concrete structural components should not be regarded as an aging mechanism for license renewal.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures," American Concrete Institute, ACI 209R-82.

3. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

APPENDIX G - SHRINKAGE

1.0 MECHANISM DESCRIPTION[1]

A workable concrete mix typically contains more water than is needed to offset the effects of hydration. When concrete is exposed to air, large portions of the free water evaporate. As water evaporates, capillary tension develops in the water remaining in the concrete while the concrete dries and shrinks in volume. Should these stresses exceed the tensile strength of the concrete, a crack forms. Initial shrinkage occurs during curing and continues months after placement. Subsequent drying and shrinkage occurs in concrete that is not continuously wet or submerged. According to ACI 209R-82[2], 91% of the shrinkage occurs during the first year, 98% in 5 years, and 100% in 20 years.

Excessive shrinkage causes cracking of the concrete surfaces, which provides a means for aggressive elements to make contact with the embedded steel/rebar, thus promoting the possibility of corrosion. The aging mechanism due to corrosion of embedded steel/rebar is discussed in Appendix E.

2.0 EVALUATION

2.1 Conditions

There is no condition in CCNPP that could aggravate the effect of concrete shrinkage initiated right after concrete construction. Most of the concrete shrinkage will have occurred well before the time of a license renewal application. Therefore, shrinkage of concrete structural components should not be regarded as an aging mechanism for license renewal.

2.2 Potential Aging Mechanism Determination

Shrinkage is not a potential aging mechanism for any Auxiliary Building concrete structural components because shrinkage in concrete proceeds at a decreasing rate with age and is not expected to continue after 40 years.

2.3 Impact on Intended Functions

Since shrinkage is not a potential aging mechanism, it will not affect the intended functions of any Auxiliary Building structural components.

2.4 Design and Construction Considerations

Since shrinkage can be minimized by keeping the water content of the paste as low as possible, the use of low slump concrete is a major factor in controlling shrinkage.[3] As stated in paragraph 12.1.2.1 of CCNPP design specification No. 6750-C-9,[4] a nominal slump of 2 inches (4,000 psi strength) was specified for all concrete used in Auxiliary Building foundation mat and lower levels. A nominal slump of 3 inches (3,000 psi strength) was specified for the upper levels of the Auxiliary Building.

The development of concrete cracking due to shrinkage is also minimized by providing adequate reinforcing steel, per the ACI 318-63 Code.

Since low slump, high strength, concrete is used at Calvert Cliffs to minimize concrete cracks from shrinkage and additional rebars are used to mitigate crack propagation, shrinkage of any concrete component of the Auxiliary Building is minimal.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Shrinkage in concrete is not a long-term aging mechanism and is not expected to continue after 40 years.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures," American Concrete Institute, ACI 209R-82

3. *Design and Control of Concrete Mixtures*, 11th Edition, Portland Cement Association, July 1968.

4. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

APPENDIX H - ABRASION AND CAVITATION

1.0 MECHANISM DESCRIPTION[1]

As water moves over concrete surfaces, it can carry abrasive materials or it can create a negative pressure (vacuum) that can cause abrasion and cavitation. If significant amounts of concrete are removed by either of these processes, pitting or aggregate exposure occurs due to loss of cement paste. These degradations are readily detected by visual examination in accessible locations.

Abrasion and cavitation occur only in concrete structures that are continuously exposed to flowing water. Cavitation damage is not common if velocities are less than 40 fps. In closed conduits, however, degradation due to cavitation can occur at velocity as low as 25 fps when abrupt changes in slope or curvature exist.

2.0 EVALUATION

2.1 Conditions

Neither the Auxiliary Building nor its structural components are exposed to continuously flowing water.

2.2 Potential Aging Mechanism Determination

Attack by abrasion and cavitation is not a potential aging mechanism for the structural components of the Auxiliary Building because the CCNPP Auxiliary Building is not exposed to continuously flowing water.

2.3 Impact on Intended Functions

Not applicable.

2.4 Design and Construction Considerations

Not applicable.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

The CCNPP Auxiliary Building nor any of its structural components are exposed to continuously flowing water. Therefore, abrasion and cavitation are not a potential aging mechanism for any structural components of the Auxiliary Building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

APPENDIX I - CRACKING OF MASONRY BLOCK WALLS

1.0 MECHANISM DESCRIPTION[1]

Masonry Block Walls

Masonry blocks walls can be designed as structural or shield walls. Masonry block wall cells may or may not contain reinforcing steel to provide structural strength for the wall. The extent of grouted cells varies with the specific design requirements for a bearing wall.

Some aging mechanisms that affect masonry block walls are the same as those that affect reinforced concrete walls. The potential for embedded steel and reinforced steel corrosion in block walls is similar to that of reinforced concrete.

Masonry block walls are vulnerable to aging mechanisms. Any restraint imposed on a masonry block wall that will prevent the wall from free expansion or contraction will induce stresses within the wall. Restraint against expansion results in small stresses depending on the strength of the block wall materials and thus rarely causes degradation of the concrete block wall. Moreover, expansion of the wall is offset by shrinkage from carbonation and drying. Restraint against free contraction causes tensile stresses within the wall. If these stresses exceed the tensile strength of the unit, the bond strength between the mortar and the unit, or the shearing strength of the horizontal mortar joint, cracks occur to relieve the stresses. Expansion or contraction of masonry block walls may be caused by changes in temperature, changes in moisture content of the constituent materials, carbonation, and movement of adjacent structural components (e.g., supporting floor or foundations).

Shrinkage due to moisture loss is among the principal causes of volume changes in masonry block walls. Factors affecting the drying shrinkage are the type of aggregate used, the method of curing, and the method of storage. Units made with sand and gravel aggregate will normally exhibit the least shrinkage; those with pumice, the highest. The difference between the moisture content of the masonry units during construction and the building in use will determine the amount of shrinkage that occurs. High-pressure steam curing and proper drying of concrete masonry units reduce the potential shrinkage of the walls.

If proper isolation is not provided at the joint between the masonry block wall and the supporting structural components (e.g., floor slabs or beams),

long-term creep and variation in stiffness of the supporting components can also cause cracking.

Durability of the masonry mortar used at the block joints may affect the long-term structural integrity of the masonry block wall. Although aggressive environments and the use of unsound materials may contribute to the deterioration of mortar joints, most degradation results from water entering the concrete masonry and freezing.

The mechanisms cited above which cause cracking of concrete block walls are age-related. Although they are ongoing processes throughout a plant's life, most cracking occurs in the early stages of plant operation.

Concrete Block Shield Walls

Solid concrete blocks used for shielding are solid masonry blocks. The discussions above for Masonry Block Walls are also applicable to Concrete Block Shield Walls.

2.0 EVALUATION

2.1 Conditions

Masonry Block Walls

Masonry block walls exist on every floor level of the Auxiliary Building. The walls are only restrained at the top and bottom.

Concrete Block Shield Walls

Concrete Blocks (Shielding) are also located throughout the Auxiliary Building. The blocks are solid concrete with densities between 130 and 140 pcf. The concrete blocks are stacked to form walls which are then laced with steel for stability and strength. Horizontal and vertical concrete block joints are mortared. Concrete Block Shield Walls are supported by plate anchorages to the floor slab; they are not restrained between existing concrete walls or slabs.

2.2 Potential Aging Mechanism Determination

Cracking of Masonry Walls is a potential aging mechanism for the following structural components of Auxiliary Building because they could be exposed to conditions that are conducive to cracking of Masonry Block Walls and Concrete Block Shield Walls, as discussed in Section 1.0:

- Concrete Blocks (Shielding) LR function LR-S-2
- Masonry Block Walls LR functions LR-S-1, 2, 5, 6, 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If the effects of cracking of the Masonry Block Walls and Concrete Block Shield Walls were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect the intended functions of the components listed in Section 2.2.

2.4 Design and Construction Considerations

The Masonry Block Walls and Concrete Block Shield Walls complies with CCNPP's design specification, 6750-A-2[2], which assured proper moisture

content, aggregates, curing and storage to reduce the possibility of cracking. Additionally, the walls are not fully restrained, are not exposed to outside weather conditions, and are fabricated with sand and gravel aggregates.

All safety-related block walls located at Calvert Cliffs Nuclear Power Plant (CCNPP) were reevaluated per NRC Bulletin 80-11. In order to perform the required reevaluation, the condition of the blockwalls and the types of equipment attached were identified during extensive walkdowns. All walls were found to be constructed satisfactorily and were qualified by calculation, using elastic design criteria. BG&E response to this I.E. Bulletin is discussed in the UFSAR Supplementary Material, located in the beginning of Volume 1 of the CCNPP UFSAR, Revision 17[3].

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, and on a walkdown performed in November, 1994[4], which inspected the accessible portions of approximately 15 walls and found no cracks, cracking of Masonry Walls is not a plausible aging mechanism for the Auxiliary Building Masonry Walls or the Concrete Block Shield Walls.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair cracking of Masonry Block Walls or Concrete Block Shield Walls inside the Auxiliary Building. Since cracking of Masonry Block Walls is not a plausible aging mechanism for the Masonry Block Walls or the Concrete Block Shield Walls in the Auxiliary Building, no management program is necessary.

3.0 CONCLUSION

Since the Masonry Block Walls and the Concrete Block Shield Walls are constructed with constituents that resist cracking; were properly cured and stored; are only restrained in one direction; are not exposed to outside weather and show no signs of cracking[3]; degradation due to cracking of the Masonry Block Walls in the Auxiliary Building is not plausible.

4.0 RECOMMENDATION

Cracking of Masonry Block Walls is not a plausible aging mechanism for any structural component in the Auxiliary Building No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Specification for Furnishing, Delivery and Erection of the Building Masonry - Calvert Cliffs Nuclear Power Plant Units No. 1& 2", Specification 6750-A-2, Rev. 1, September, 1970.

3. Calvert Cliffs Nuclear Power Plant Units 1 and 2, Updated Final Safety Analysis Report UFSAR Supplementary Material, Rev. 17, Supplementary Material (Located at beginning of Volume 1).

4. Walkdown - Auxiliary Building, November, 1994.

APPENDIX J - SETTLEMENT

1.0 MECHANISM DESCRIPTION[1]

All structures settle during construction and for months after construction. The amount of settlement depends on the physical properties of foundation material. These properties range from rock (with little or no settlement likely) to compacted soil (with some settlement expected). Settlement may occur during the design life from changes in environmental conditions, such as lowering of the groundwater table. Settlement can occur in two stages: elastic expansion and time-dependent settlement. Elastic expansion of the confined soil occurs due to excavation unloading and results in a slightly upward movement. During construction, the soil moves downward as load is applied. This elastic movement should be small and is complete when construction is completed. It has no effect on the structure and is not considered an aging mechanism[2]. The excavation unloading and structural loading cause a small change in the void ratio of the soil. This change results in a very small amount of time-dependent settlement. The settlement rate will decline after completion of construction.

Settlement of structures is usually small and is typically determined by survey. Concrete and steel structural members can be affected by differential settlement between supporting foundations, within a building, or between buildings. Severe settlement can cause misalignment of equipment and lead to overstress conditions within the structure[3]. When buildings experience significant settlement, cracks in structural members, differential elevations of supporting members bridging between buildings, or both may be visibly detected.

2.0 EVALUATION

2.1 Conditions[2]

The foundation mat elevation of the Auxiliary Building at CCNPP varies from approximately 50 feet to 70 feet below the average ground elevation. The foundation mat is situated on Miocene soil, which is exceptionally dense and will support heavy foundation loads. The major soil types are sandy silts, silty sands, and slightly clayed sands. The ultimate bearing capacity of the foundation strata is in excess of 80,000 psf, and the allowable bearing capacity is 15,000 psf. However, the design bearing pressure of the foundation mat is 8,000 psf. The soil bearing pressure was about the same as the overburden removed due to excavation.

2.2 Potential Aging Mechanism Determination

Settlement is a potential aging mechanism for all structural components in the Auxiliary Building. However, since the concrete foundation mat is the only structural component directly supported by the soil media, and also for convenience of discussion, only the concrete foundation mat is identified as the structural component subject to the aging mechanism due to settlement.

- Concrete foundation mat LR-S-1, 5

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

2.3 Impact on Intended Functions

If the effects of settlement were not considered in the original design or are allowed to degrade the above structural component unmitigated for an extended period of time, this aging mechanism could affect the functions of the concrete foundation mat.

2.4 Design and Construction Considerations

In addition to soil bearing capacity, settlement of the Auxiliary Building foundation mat was also investigated in the design of the Auxiliary Building. A maximum post-construction settlement of 1/2 inch was predicted in the original Auxiliary Building design[2]. Since the concrete mat is a rigid foundation and is situated on a exceptionally dense soil, the Auxiliary Building tends to uniformly settle as a rigid body. Most of the predicted 1/2 inch settlement is in terms of uniform settlement, which has no adverse effect on the structural components of the Auxiliary Building. A small fraction of the 1/2 inch settlement will be in terms of differential settlement. It is so small that the effect on the structural component is negligible.

The excavation for the Auxiliary Building was below the groundwater table. A dewatering system was installed during plant construction to maintain the groundwater table at El. 10'-0".[2] This groundwater table level was considered in the original design of all underground structures.[3]

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, the soil type at the CCNPP Auxiliary Building is exceptionally dense, and the design bearing pressure is about the same as that of the removed overburden and is much smaller than the allowable bearing capacity. As discussed in Section 2.4, the predicted settlement is small and the differential settlement is negligible. A dewatering system was installed to minimize the fluctuation of groundwater table, thus providing stable geological conditions of the plant site. Therefore, settlement is not a plausible aging mechanism for any structural components of the Auxiliary Building.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage to concrete incurred by settlement. Since this is not a plausible aging mechanism that could degrade the Auxiliary Building structural components, no management program is necessary.

3.0 CONCLUSION

CCNPP's Auxiliary Building is situated on Miocene soil, which is exceptionally dense and will support heavy foundation loads. Additionally, the structural load on the foundation mat is about the same as the removed overburden weight. Therefore, the soil bearing stress is well below its ultimate bearing capacity, and the long-term settlement is predicted to be only 1/2 inch.[2] In addition, the settlement rate declined after completion of construction. Long-term settlement is not expected to continue after 40 years. Therefore, settlement is not a plausible aging mechanism for the structural components of the Auxiliary Building.

4.0 RECOMMENDATION

Settlement is not a plausible aging mechanism for the concrete foundation mat of the Auxiliary Building and requires no further evaluation or recommendation.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Calvert Cliffs Nuclear Power Plant, Units 1 and 2, Updated Final Safety Analysis Report (UFSAR)," Baltimore Gas and Electric Co.

3. Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant, Units 1 and 2, by Bechtel Power Corporation, Revision 0, August 2, 1991.

APPENDIX K - CORROSION OF STEEL

1.0 MECHANISM DESCRIPTION[1]

Steel corrodes in the presence of moisture and oxygen as a result of electrochemical reactions. Initially, the exposed steel surface reacts with oxygen and moisture to form an oxide film as rust. Once the protective oxide film has been formed and if it is not disturbed by erosion, alternating wetting and drying, or other surface actions, the oxidation rate will diminish rapidly with time. Chlorides, either from sea water, the atmosphere, or groundwater, increase the rate of corrosion by increasing the electrochemical activity. If steel is in contact with another metal that is more noble in the galvanic series, corrosion may accelerate.

In some cases, corrosion of structural steel in contact with water may be microbiologically induced due to the presence of certain organisms, which is sometimes referred to as microbiologically influenced corrosion (MIC). These organisms, which include microscopic forms such as bacteria and macroscopic types such as algae and barnacles, may influence corrosion on steel under broad ranges of pressure, temperature, humidity, and pH. MIC effects on carbon steel may result in random pitting and general corrosion.

The rate of steel corrosion depends on site-specific environmental conditions and measures taken to prevent corrosion. A steel structure surface subjected to alternately wet and dry conditions corrodes faster than one exposed to continuously wet conditions. Atmospheric corrosion proceeds much more rapidly in areas where the atmosphere is chemically polluted by vapors of sulfur oxides and similar substances. Steel will corrode much faster in the vicinity of sea water because of sodium chloride in the atmosphere. The corrosion rate of steel usually increases with rising temperatures.

Corrosion products such as hydrated oxides of iron (rust) form on exposed, unprotected surfaces of the steel and are easily visible. The affected surface may degrade such that visible perforation may occur. In the case of exposed surfaces of structural steel with protective coatings, corrosion may cause the protective coatings to lose their ability to adhere to the corroding surface. In this case, damage to the coatings can be visually detected well in advance of significant degradation.

2.0 EVALUATION

2.1 Conditions

Steel can corrode in the presence of moisture and oxygen as a result of electrochemical reactions, especially in areas where there is an inadequate drainage system. Structural steel components especially vulnerable to corrosion are those members that are in areas that can form pockets to harbor liquids.

2.2 Potential Aging Mechanism Determination

Corrosion is a potential aging mechanism for the following Auxiliary Building structural steel components because conditions conducive to steel corrosion discussed in Sections 1.0 and 2.1 exist:

- Steel columns — LR functions LR-S-1, 5
- Steel beams — LR functions LR-S-1, 5
- Base plates — LR functions LR-S-1, 5
- Floor framing — LR functions LR-S-1, 5
- Roof framing/trusses — LR functions LR-S-1, 4, 5
- Steel bracing — LR functions LR-S-1, 5
- Platform hangers — LR functions LR-S-1, 5
- Decking — LR functions LR-S-1, 5
- Jet Impingement Barriers — LR functions LR-S-1, 5
- Fire Doors, Jambs, & Hardware — LR function LR-S-7
- Access Doors, Jambs, & Hardware — LR function LR-S-2
- Watertight Doors — LR function LR-S-6, 7
- Roll-up Doors — LR function LR-S-2
- New Fuel Rack Assembly — LR function LR-S-1

•	Monorail	LR function LR-S-5
•	Cask Handling Crane Rail/Supts	LR function LR-S-1, 5
•	Pipe Whip Restraints	LR function LR-S-2
•	Cast-in-place anchors	LR functions LR-S-1
•	Post-installed anchors	LR function LR-S-1

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If corrosion of steel is allowed to degrade the above structural steel components unmitigated for an extended period of time, this aging mechanism could affect all intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

Since corrosion was considered a potential degradation mechanism for all structural steel components of the Auxiliary Building, its effects were considered in the original design. As a result, all exposed structural steel surfaces in the Auxiliary Building except grating, checkered plates, and metal decking, which are galvanized steel, were shop-painted or field-painted during the construction phase in accordance with CCNPP's design specifications No. 6750-C-31[2] and No. 6750-A-24[3].

Maintenance of protective coatings on CCNPP's equipment and structures follows the requirements specified in Calvert Cliffs Nuclear Program Interdepartmental Procedure MN-3-100[4]. This program sets forth procedural controls that comply with 10 CFR Part 50, Appendix B and satisfy the protective coating requirements in Regulatory Guide 1.54 which endorses ANSI N101.4-1972. This MN provides the requirements for coating and recoating new structural components and the refurbishment of existing structural components in the Auxiliary Building (as well as the Containment and balance of plant). Application of coatings at CCNPP follows standard procedures specified in TRD-A-1000[5].

Galvanic material on steel components is one of the protective coating systems. Maintenance of galvanic coatings is covered under the same maintenance program as paint and other protective coatings.

2.5 Plausibility Determination

Based on the discussion in Sections 2.1, 2.3 and 2.4, corrosion could affect the intended functions of all structural steel members and is, therefore, a plausible aging mechanism for all steel components listed in Section 2.2.

2.6 Existing Programs

System engineer walkdowns under PEG-7[6] will provide the discovery mechanism for degraded coating conditions. Conditions adverse to quality (such as degraded paint or corrosion) are reported in an Issue Report under QL-2-100[7]. The coatings program under MN-3-100[5] provides the administrative control over how corrective actions are performed. The combination of these existing plant programs will ensure that corrosion effects on accessible structural steel are adequately managed. These programs do not provide for the evaluation of the coating condition on structural steel components that are not normally accessible. An age related degradation inspection program as defined in the BGE Integrated Plant Assessment Methodology is necessary to address the aging effects of the non-accessible structural steel components.

3.0 CONCLUSION

All structural steel components of CCNPP's Auxiliary Building are vulnerable to corrosion attack if a corrosive environment prevails. All exposed structural steel surfaces in the Auxiliary Building are covered by a protective coating. Aging management of degraded coating conditions on accessible structural steel in the Auxiliary Building is accomplished through the combination of existing plant programs. However, structural steel components not readily accessible require additional aging management.

4.0 RECOMMENDATION

All painted and galvanized structural steel components in the Auxiliary Building should be inspected to evaluate the condition of the coating, and repaired as required

Coatings on structural steel in accessible areas are adequately managed by existing plant programs. A new program utilizing an age related degradation inspection should be developed to address degradation of coatings on structural steel components that are not normally accessible.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Specification for Furnishing, Detailing, Painting, and Delivering Containment and Auxiliary Building Structural Steel," CCNPP's Design Specification No. 6750-C-31, Revision 2, May 1970.

3. "Specification for Painting and Special Coatings," CCNPP's Design Specification No. 6750-A-24, Revision 12, October 1982.

4. "Painting and Other Protective Coatings," CCNPP's Administrative Procedure MN-3-100, Rev. 2.

5. "Coating Application Performance Standard," TRD-A-1000, Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2, Revision 8, August 1991.

APPENDIX L - CORROSION OF LINER

1.0 MECHANISM DESCRIPTION[1,2]

1.1 Spent Fuel Pool Stainless Steel Liner

The stainless steel liner may be subject to stress corrosion cracking (SCC), which is defined as cracking under the combined actions of corrosion and tensile stresses. The phenomenon of SCC can result in fracture of the metal. The stresses may be either applied (external) or residual (internal). The stress corrosion cracks themselves may be either transgranular or intergranular, depending on the metal and the corrosive agent. As is normal in all cracking, the cracks are perpendicular to the tensile stress. Usually there is little or no obvious visual evidence of corrosion. The three principal factors necessary to initiate stress corrosion cracking are tensile stresses, corrosive environment, and susceptible material. The tensile stresses necessary to cause SCC must be at or near the material's yield point. This is facilitated when the material is substantially cold worked, contains residual stress from welding, or is subjected to significant applied loads. Different corrosive environments induce different levels of SCC on various materials. With respect to material susceptibility, austenitic stainless steels, such as SA-240 Type 304, are prone to SCC, particularly when sensitization is present as in heat-affected zones and at creviced geometries.

In a sensitized condition, Type 304 stainless steel may develop intergranular stress corrosion cracking (IGSCC). The heat-affected zones of welds in Type 304 stainless steel are potential sites for IGSCC. IGSCC occurs when changes in the microstructure take place due to the welding heat, rendering the heat-affected zones "sensitized", and when high residual stresses occur in and around the welds. The degree of sensitization depends on the metal's composition. For example, sensitization usually occurs when Cr in boundaries combines with carbon. A low carbon content stainless steel, such as Type 304L, is relatively immune to IGSCC in the fuel pool environments. This is because the low carbon content (0.03 percent maximum) of Type 304L results in sensitization levels during welding so low that its heat-affected zones are resistant to IGSCC in the fuel pool environments.

1.2 Spent Fuel Racks

Spent Fuel Racks are fabricated from thin stainless steel material and are also submerged in borated water, as are the liner plates. Therefore, the mechanism descriptions provided in section 1.1, above, are applicable for Spent Fuel Racks.

2.0 EVALUATION

The stainless steel liner and the Spent Fuel Racks do not have dissimilar metals; therefore, they are not subject to galvanic corrosion.

2.1 Conditions

Spent Fuel Pool Liner

The Spent Fuel Pool liner at CCNPP is SA-240 Type 304 stainless steel.[3] The liner was constructed from a series of individual steel plates welded together. Both the plate material and the welds are subject to the same potential degradation mechanisms. The significance of potential degradation of the liners is considered to apply equally to the plate material and the welds.[1]

SA-240 Type 304 stainless steel used for the Spent Fuel Pool Liner is resistant to electrochemical corrosion in the spent fuel pool environments. The corrosion rate of this steel ranges from 0.05 mil in 100 years (virtually no corrosion) to less than 0.01 mil per year in a borated fuel pool water environment.[4] Therefore, the electrochemical corrosion is negligible and is not a potential aging mechanism for the stainless steel liner.

The stainless steel liner in the Spent Fuel Pool is not a load-bearing structural component. The induced strains in the liner, resulting from conformation to deformation of the concrete wall of the Spent Fuel Pool, are negligible under normal plant operating conditions. The liner is not exposed to corrosive environmental conditions under normal operating conditions. Therefore, the conditions for SCC to occur do not exist for the stainless steel liner in the Spent Fuel Pool.

The heat-affected zones of welds at the stainless steel liner are potential sites for "sensitization." Sensitized Type 304 stainless steel is susceptible to IGSCC in boric acid solution.[1] Degradation of the stainless steel liner due to IGSCC in the liner is typically evidenced by leakage and detected by observation of an increased amount of pool water leakage.

Spent Fuel Racks

The Spent Fuel Racks are high density racks installed in the 1980's and are fabricated from Type 304L stainless steel[6]. Per reference 1, Type 304L is relatively immune from IGSCC and as such is not a plausible aging mechanism for the racks.

The Spent Fuel Rack stainless steel is a load-bearing structural component. However, the induced stresses in the plates and welds, due to supporting spent fuel assemblies, are very small under normal plant operating conditions. Additionally, the racks are fabricated from Type 304L stainless steel, which makes the welds potentially susceptible to IGSCC in the spent fuel pool environment.[1]

2.2 Potential Aging Mechanism Determination

Corrosion is a potential aging mechanism for the following structural components of Auxiliary Building because conditions exist that are conducive to corrosion of stainless steel liner plates, as discussed in Section 1.0:

- Spent Fuel Pool Liner (stainless steel liner) — LR function LR-S-3
- Spent Fuel Racks (stainless steel) — LR function LR-S-1

where:

LR-S-1: Provides structural and/or functional support, or both, to safety-related equipment.

LR-S-3: Serves as a pressure boundary or fission product retention barrier to protect public health and safety in the event of any postulated DBEs.

2.3 Impact on Intended Functions

If the effects of corrosion of the liner and racks were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect the intended functions of the components listed in Section 2.2.

2.4 Design and Construction Considerations

The Spent Fuel Pool Liner was not designed to carry any design loads and was designed only as a leaktight barrier.[3] Under normal operating conditions, the imposed strain on the liner due to conforming to concrete

deformation is very small and is negligible because the stresses in the Spent Fuel Pool concrete components are minimal.

The Spent Fuel Racks were designed to carry design loads (dead loads and seismic). Under normal operating conditions, the imposed strain on the racks, due to the dead weight of the fuel assemblies, is very small.

2.5 Plausibility Determination

Based on the discussion in Section 2.1, corrosion in sensitized zones of the Spent Fuel Pool Liner due to IGSCC is a plausible aging mechanism.

Based on the discussion in Section 2.1, corrosion in the sensitized zones of the Spent Fuel Racks due to IGSSC is not a plausible aging mechanism

2.6 Existing Programs

Leakage of the Spent Fuel Pool is addressed by leakage testing described in OI-24D[5].

The Spent Fuel Pool Liner is fabricated from stainless steel plate, welded together at channel leak chases. These leak chases flow to "telltale valves". There are a total of ten valves in the SFP (four vertical and one floor for each unit). Monthly, the valves are opened, drained, and are monitored for 24 hours with drip bags. Historically, no more than several hundred cubic centimeters of water have been collected during the 24 hours, and frequently no water is reported. The water that has been collected has always been shown not to be borated, therefore, most likely, not even from the SFP. With approximately 600,000 gallons of water in the SFP, the potential leakage of less than a liter of water is insignificant. Additionally, pumps capable of supplying up to 160 GPM, are available, continuously, to provide pool makeup water if necessary.

3.0 CONCLUSION

For the stainless steel liner of the Spent Fuel Pool, degradation due to IGSCC of heat-affected zones of welds may cause the liner to leak. Therefore, IGSCC of the stainless steel liner is a plausible aging mechanism for the Spent Fuel Pool Liner.

As noted in Section 2.1, degradation due to IGSCC of heat-affected zones of welds in not a plausible aging mechanism for the Spent Fuel Racks.

4.0 RECOMMENDATION

Based on the above discussion, the following recommendation is made:

Since, historically, leakage of the SFP has been shown to be negligible and since programs are in place that periodically monitor for leakage (per the existing programs, an Issue Report would be generated if any appreciable amount of borated water or if excessive leakage is noted in the "telltale" valves), no further action is required.

5.0 REFERENCES

1. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-01, Revision 1, September 1991.

2. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

3. "Specification for Stainless Steel Liner Plate and Spent Fuel Pool Bulkhead Gate," CCNPP's Design Specification No. 6750-C-28, Revision 5, June 1973.

4. "Safety Evaluation Report Related to the Operation of Comanche Peak Steam Electric Station, Units 1 and 2," NUREG-0797, July 1981.

5. "Spent Fuel Pool Cooling - Infrequent Operations", Operating Instructions OI-24D, Rev. 0

6. "Safety Evaluation by the Office of Nuclear Reactor Regulation Supporting Amendment Nos. 47 and 30 to Facility Operating License Nos. DPR-53 and DPR-69 Relating to Modification of the Spent Fuel Pool Baltimore Gas & Electric Company Calvert Cliffs Nuclear Power Plant Unit Nos. 1 & 2, Docket Nos. 50-317 and 50-318", September 1980.

APPENDIX M - CORROSION OF TENDONS

1.0 MECHANISM DESCRIPTION[1]

When corrosion of prestressing tendons occurs, it is generally in the form of localized corrosion. Most corrosion-related failures of prestressing tendons have been attributed to pitting, stress corrosion, hydrogen embrittlement, or some combination of these.

Pitting is a highly localized form of corrosion. The primary parameter affecting its occurrence and rate is the environment surrounding the metal. The presence of halide ions, particularly chloride ions, is associated with pitting corrosion.

Stress corrosion results from the simultaneous presence of a conducive environment, a susceptible material, and tensile stress. The environmental factors known to contribute to stress corrosion cracking (SCC) in carbon steels are hydrogen sulfide, ammonia, nitrate solutions, and seawater. Prestressing tendon anchor heads, which are constructed of a high strength, low alloy steel bolting material, are vulnerable to SCC.

Hydrogen embrittlement (technically, not a form of corrosion) occurs when hydrogen atoms, produced by corrosion or excessive cathodic protection potential, enter the metal lattice. Hydrogen produced by corrosion is not usually sufficient to result in hydrogen embrittlement of carbon steel. Cathodic polarization is the usual method by which this hydrogen is produced. The interaction between the dissolved hydrogen atoms and the metal atoms results in a loss of ductility manifested as brittle fracture.

Corrosion of prestressing wires causes cracking or a reduction in the wires' cross-sectional area. In either case, the prestressing forces applied to the concrete are reduced. If the prestressing forces are reduced below the design level, a reduction in design margin results.

2.0 EVALUATION

2.1 Conditions

Not applicable. There are no tendons in the Auxiliary Building.

2.2 Potential Aging Mechanism Determination

Not applicable.

2.3 **Impact on Intended Functions**

Not applicable.

2.4 **Design and Construction Considerations**

Not applicable.

2.5 **Plausibility Determination**

Not applicable.

2.6 **Existing Programs**

Not applicable.

3.0 CONCLUSION

Corrosion of tendons is not a plausible degradation mechanism for CCNPP's Auxiliary Building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-1, Revision 1, September 1991.

APPENDIX N - PRESTRESS LOSSES

1.0 MECHANISM DESCRIPTION[1]

As the plant ages, tendons that were prestressed during construction tend to lose tension. Termed prestress losses, these reductions in stress are not readily observable. Several factors contribute to prestress losses:

- Stress relaxation of prestressing wires
- Shrinkage, creep, and elastic deformation of concrete
- Anchorage seating losses
- Tendon friction
- Reduction in wire cross section due to corrosion

With the exception of corrosion-induced wire cross-sectional loss, predictions of prestress losses were calculated during design to ensure the containment can maintain its pressure capacity under postulated DBE inside the containment.

2.0 EVALUATION

2.1 Conditions

Not applicable. There are no tendons in the Auxiliary Building.

2.2 Potential Aging Mechanism Determination

Not applicable.

2.3 Impact on Intended Functions

Not applicable.

2.4 Design and Construction Considerations

Not applicable.

2.5 **Plausibility Determination**

Not applicable.

2.6 **Existing Programs**

Not applicable.

3.0 CONCLUSION

Prestress losses is not a plausible degradation mechanism for CCNPP's Auxiliary Building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-1, Revision 1, September 1991.

APPENDIX O - WEATHERING

1.0 MECHANISM DESCRIPTION [1]

Components and structures that are located in an environment that is exposed to ambient conditions are susceptible to degradation due to weathering (indoor or outdoor). Aging mechanisms associated with weathering include exposure to sunlight (ultraviolet exposure), changes in humidity, ozone cycles, temperature and pressure fluctuations, and snow, rain, or ice. The effects of weathering on most materials are evidenced by a decrease in elasticity (drying out), an increase in hardness, and shrinkage.

2.0 EVALUATION

2.1 Conditions

According to Specification ASTM C33-82, "Standard Specification for Concrete Aggregates," [2] the CCNPP site is located in the geographic region subject to severe weathering conditions. All outdoor components will experience the extreme temperature ranges, rain, snow, and changes in humidity expected at the CCNPP site. Additionally, inside the Auxiliary Building, components will also experience similar temperature and humidity changes, throughout the life of the plant.

2.2 Potential Aging Mechanism Determination

Degradation by weathering is a potential aging mechanism for the following Auxiliary Building components because they are exposed to outdoor conditions or similar in-building conditions:

- caulking and sealants — Functions LR-S-2, 6, and 7
- expansion joints (joint material) — Functions LR-S-2 and 7

where:

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-6: Provides flood protective barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If the effects of weathering were not considered in the original design or are allowed to degrade the above components unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of the components listed in Section 2.2.

2.4 Design and Construction Considerations

The caulking and sealants and expansion joints are components which are typically replaced on condition. However, inspections have indicated that a program of inspection and maintenance is required to be developed. Issue Report IR1995-01698 [3] was written to address this issue.

2.5 Plausibility Determination

Based on the discussion in Sections 2.3 and 2.4, weathering has been determined to be plausible for the caulking and sealants and expansion joints in the CCNPP Auxiliary Building.

2.6 Existing Programs

The caulking and sealants and expansion joints which perform a fire barrier function are addressed under the Appendix R Program as implemented by procedure STP-F-592-1/2 [4] for penetration fire barrier inspection. This procedure was determined to be adequate for managing the effects of weathering for the caulking and sealants and expansion joints.

3.0 CONCLUSION

Weathering is a plausible aging mechanism for the caulking and sealants and expansion joints in the Auxiliary Building. Management of the aging mechanism for caulking and sealants and expansion joints which perform functions other than fire barrier will be established in conjunction with the resolution to Issue Report IR1995-01698. The Appendix R Program addresses the aging management for caulking and sealants and expansion joints which perform a fire barrier function.

4.0 RECOMMENDATION

Caulking and sealants and expansion joints which act as fire barriers are currently maintained through implementation of the Appendix R inspection program (STP-F-592-1/2). However, caulking and sealants and expansion joints which perform intended functions other than fire barrier do not have a program to manage their aging. An inspection program should be established in conjunction with the resolution to Issue Report IR1995-01698 to manage the effects of weathering for the caulking and sealants and expansion joints not included under the Appendix R Program.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Standard Specification for Concrete Aggregates," American Society of Testing and Materials, ASTM C33-82.

3. BGE Issue Report IR1995-01698, Building Joints (Aux. Bldg. Exterior), dated 07/13/95.

4. "Penetration Fire Barrier Inspection," CCNPP's Surveillance Test Procedure, STP-F-592-1/2

APPENDIX R - ELEVATED TEMPERATURE

1.0 MECHANISM DESCRIPTION[1]

During normal plant operation, solar heat load and equipment heat loads contribute to an increase in temperature of the internal environment of a structure. Of all structural components in a structure, only components made of concrete material are potentially affected within the temperature range in which the structure will experience during normal plant operating conditions. As a result of elevated temperature, compressive strength, tensile strength, and the modulus of elasticity of concrete could be reduced by greater than 10 percent in the temperature range of 180 to 200 °F. Long-term exposure to high temperatures (> 300 °F) may cause surface scaling and cracking. Otherwise, there is no visible physical manifestation of concrete degradation due to exposure to elevated temperature.

ASME Code[2], Section III, Division 2 indicates that as long as concrete temperatures do not exceed 150 °F, aging due to elevated temperature exposure is not significant. Localized hot spots are limited in area and do not exceed 200 °F by design. ACI-349[3] allows local area temperatures to reach 200 °F before special provisions are required.

2.0 EVALUATION

2.1 Conditions

Section 5.2.2 of Appendix B of the Baltimore Gas and Electric Company's EQ Manual[4] states:

> *"Reference 102 documents specific maximum average component temperatures for the MSIV Room 309 as 151.9°F with a maximum variation of 1°F during the day."*

The EQ Manual notes that the MSIV rooms are the only areas of the Auxiliary Building to have a potential maximum ambient temperature above 150°.

2.2 Potential Aging Mechanism Determination

Elevated temperature is a potential aging mechanism for the following concrete structural components of the Auxiliary Building because they could be exposed to temperatures higher than the degradation threshold of elevated temperature for concrete (150 °F):

- Concrete columns, walls, elevated floor slabs, equipment pads and grout (MSIV Rooms) — LR functions LR-S-1, 5, and 6

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

Structural components in other areas of the Auxiliary Building are not exposed to temperatures higher than the degradation threshold of elevated temperature for concrete. Therefore, elevated temperature is not a potential aging mechanism for these components.

2.3 Impact on Intended Functions

If the effects of elevated temperature are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

The maximum ambient temperatures inside the Auxiliary Building during normal plant operation is less than 150°, per Reference 4, Appendix B, Table B-1, except for the MSIV rooms. These temperatures are below the degradation thresholds of elevated temperature for concrete.

The higher temperature of 151.9 °F noted in Section 2.1 is limited to the MSIV rooms. Since temperatures on the other side of the concrete walls and slabs would typically be more than 50°F less than this maximum, the temperature in the concrete, conservatively assuming linear heat loss, would reduce to 150°F within the first inch of the concrete. And since concrete outside the rebar layers are not considered in the strength designs, the room temperatures of 151.9°F will not degrade the concrete in the MSIV rooms.

Additionally, under BG&E Task 05559[5], the effect of ambient temperatures up to 160°F in the MSIV rooms were evaluated and found to be acceptable. A walkdown performed for the Task 05559 evaluation and a walkdown performed in November, 1994[6], for the LCM program, have confirmed that no concrete damage has occurred in the MSIV rooms, due to elevated temperature.

Also, as noted above, and in the Task 05559 evaluation, no structural degradation would be expected in concrete subjected to temperatures less than 180°F

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, no structural components in the Auxiliary Building are exposed to temperatures which would cause heat related degradation. Therefore, elevated temperature is not a plausible aging mechanism for any structural components of the CCNPP Auxiliary Building.

2.6 Existing Programs

Although there is no existing program to monitor the temperature profiles for the surfaces of the MSIV rooms noted in Section 2.4, the original design recognized the potential of elevated temperatures on concrete inside the Auxiliary Building. Therefore, no program is needed to manage this aging mechanism.

3.0 CONCLUSION

Only the MSIV rooms in the Auxiliary Building are subject to local heat buildup up to 151.9°F. However, as noted in section 2.4, this elevated temperature will not affect the design functions of the concrete slabs and walls comprising the MSIV rooms. No other structural components are exposed to elevated temperature above 150°F.

Therefore, elevated temperature is not a plausible aging mechanism for any structural components of the Auxiliary Building.

4.0 RECOMMENDATION

Elevated temperature is not a plausible aging mechanism for any structural components of the Auxiliary Building. Therefore, no further evaluation or recommendation is necessary.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Code for Concrete Reactor Vessels and Containments," ASME Boiler and Pressure Vessel Code, Section III, Division 2, 1986.

3. "Code Requirements for Nuclear Safety Related Concrete Structures," American Concrete Institute, ACI 349-85.

4. "EQ Design Manual - Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2," Baltimore Gas and Electric Co.

5. Task 05559 - Evaluation of elevated temperatures in the MSIV rooms, 1993.

6. Walkdown Report - Auxiliary Building, November, 1994.

APPENDIX S - IRRADIATION

1.0 MECHANISM DESCRIPTION[1,2]

1.1 Concrete

Concrete components in a nuclear power plant exposed to excessive neutron or gamma radiation (incident flux > 10^{10} MeV/cm^2-sec)[3] could be impaired due to aggregate growth, decomposition of water or thermal warming of concrete. As the temperature of concrete increases and free water within the concrete evaporates, the structural characteristics of concrete are degraded. With the water loss, concrete can experience a decrease in its compressive, tensile, and bonding strengths, and in its modulus of elasticity. However, this loss of free water which results in a small decrease in concrete density will have little effect on concrete's gamma attenuation properties unless water loss is significant, depleting the presence of hydrogen atoms which contribute to concrete's shielding characteristics of fast neutrons. Typically, gamma radiation affects the cement paste portion of the concrete, producing heat and causing water migration.

Existing experimental data provide some general information on the impact of direct radiation on the mechanical properties of concrete[4]. The average concrete sample does not begin to experience a compressive or tensile strength loss until exposure exceeds a neutron fluence of 10^{19} neutrons/cm^2. The experimental data[4] indicate minimal compressive loss for exposure up to 5×10^{19} neutrons/cm^2.

1.2 Reinforcing Steel, Structural Steel, and Liner

Steel degradation due to neutron irradiation is caused by the displacement of atoms from their normal lattice positions to form both interstices and vacancies. The effect of this mechanism is to increase the yield strength, decrease the ultimate tensile ductility, and increase the ductile-to-brittle transition temperature. These defects on a macroscopic level produce what is referred to as radiation-induced embrittlement, which is encountered in the design and operation of reactor pressure vessels. By comparing the currently available stress-strain curves for unirradiated and irradiated mild steel, a reduction in ductility of rebar subjected to high radiation exposure (> 10^{18} neutrons/cm^2) is indicated.[5] Neutron radiation is not a concern for the Auxiliary Building and the relatively low Gamma radiation levels in the Auxiliary Building are not an aging mechanism for steel.

2.0 EVALUATION

2.1 Conditions

Structural components are exposed to high radiation in some areas inside the Auxiliary Building, such as the Charging Pump Room and the Spent Fuel Pool area. As noted in Section 1.0, the gamma radiation degradation thresholds for concrete is:

Concrete	$5x10^9$ Rads

2.2 Potential Aging Mechanism Determination

Irradiation is a potential aging mechanism for the following structural and architectural components of the Auxiliary Building.

- concrete foundation mat
- concrete: walls, beams, columns, floors, slabs, equipment pads, grout

2.3 Impact on Intended Functions

If the effects of irradiation are allowed to degrade the above structural and architectural components unmitigated for an extended period of time, this aging mechanism could affect all their intended functions.

2.4 Design and Construction Consideration

BG&E's EQ Design Manual[6] specifies the following 40-year normal ambient for use in environmental qualification evaluations:

Unit-1 ECCS Pump Room (Maximum dose in Auxiliary Building)	$3.873x10^6$ rads

Based on the above, the allowable 60-year normal radiation doses are:

Unit-1 ECCS Pump Room	$5.81x10^6$ rads

As indicated above, the allowable 60-year radiation doses of gamma radiation incurred by the structural components are less than the irradiation degradation threshold for each constituent of all structural components. Therefore, irradiation is not a plausible age-related degradation mechanism for any structural component of the Auxiliary Building.

2.5 **Plausibility Determination**

Based on the discussion in Sections 2.1 and 2.4, no structural components in the Auxiliary Building are exposed to radiation higher than their design threshold. Therefore, irradiation is not a plausible aging mechanism for any structural or architectural components of the CCNPP Auxiliary Building.

2.6 **Existing Programs**

There are no existing programs at CCNPP designed to identify damages to structural components of the Auxiliary Building due to radiation. However, since this is not a plausible aging mechanism that could degrade these components, no future program is necessary.

3.0 CONCLUSION

No structural components in the Auxiliary Building are exposed to neutron radiation, however, some components are exposed to high levels of gamma radiation. As indicated in Section 2.0 above, the normal environmental gamma dose inside the Auxiliary Building for up to 60 years are predicted to be below the degradation threshold for each constituent of all structural components. Therefore, irradiation is not a plausible aging mechanism for the structural components of the Auxiliary Building.

4.0 RECOMMENDATIONS

Irradiation is not a plausible aging mechanism for the concrete structural components in Auxiliary Building. No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-1, Revision 1, September, 1991.

3. "Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants", American Nuclear Standard ANSI/ANS-6.4

4. Hilsdorf, H.R., Kropp, J., and Koch, H.J., "The Effects of Nuclear Radiation on the Mechanical Properties of Concrete," Douglas

McHenry International Symposium on Concrete and Concrete Structures, American Concrete Institute Publication SP-55, 1978

5. Naus, D.J., "Concrete Component Aging and its Significance Relative to Life Extension of Nuclear Power Plants," NUREG/CR-4652, ORNL/TM-10059, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1986

6. "EQ Design Manual - Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2," Baltimore Gas and Electric Co.

APPENDIX T - FATIGUE

1.0 MECHANISM DESCRIPTION[1]

Fatigue is a common degradation of structural members produced by periodic or cyclic loadings that are less than the maximum allowable static loading. Fatigue results in progressive, localized damages to structural materials.

Two types of fatigue exist for structural components. The first mechanism, sometimes referred to as low-cycle fatigue, is low frequency (<100 cycles for concrete structures and <1 x 10^5 for steel structures) of high-level repeated loads due to abnormal events such as SSE or strong winds. Structures exposed to such events must be thoroughly evaluated by analysis or by inspection or both after occurrence. The fatigue degradation caused by such loading may not occur or may occur only a few times during the service life of a structure. Therefore, low-cycle fatigue is not age-related and is not a license renewal issue.

The other fatigue mechanism is high frequency of low-level, repeated loads such as equipment vibration. Referred to as high-cycle fatigue, it is an age-related degradation mechanism.

1.1 Concrete[1]

The fatigue strength of concrete structures has become a concern due to the widespread adoption of ultimate strength design procedures and the use of high-strength materials that require concrete structural members to perform satisfactorily under high-stress levels. Repeated loading causes cracking in component materials of a member and alters its static load-carrying characteristics.

Fatigue strength of plain concrete is essentially the same whether the mode of loading is tension, compression, or flexure. The stress-to-fatigue life relationship can be represented by an S-N curve as shown in Figure T-1, where S represents the maximum stress in the cycle and N represents the number of cycles required to produce failure. A series of specimen testing determines fatigue behavior, and the results are plotted on a log-scale. At a given number of service cycles (N) the material has a defined allowable fatigue strength. Review of S-N curves of plain concrete beams in ACI report 215R-74[2] indicates the following:

- *Fatigue strength of concrete decreases with the increasing number of cycles. The S-N curves for concrete are approximately linear between 10^2 and 10^7 cycles. This indicates that there is no limiting value of stress below which the fatigue life will be infinite.*

A decrease of the range between maximum and minimum load results in increased fatigue strength for a given number of cycles. When the minimum and maximum loads are equal, the strength of the specimen corresponds to the static strength of concrete determined under normal test conditions.

The fatigue strength of plain concrete for a life of 10 million cycles for tension, compression, or flexure is roughly about 55 percent of its static strength.

Fatigue fracture of concrete is characterized by considerably larger strains and cracking as compared with fracture of concrete under static loading.

Fatigue failure of reinforcing steel has not been as significant a factor in its application as for reinforcement in concrete structure. There have been few documented cases of reinforcing fatigue failures in the concrete industry. ACI report 215R-74[2] notes that the lowest stress range known to have caused a fatigue failure of a straight hot-rolled deformed bar embedded in a concrete beam is 21 ksi. This failure occurred after 1.25×10^6 cycles of loading on a concrete beam containing a No. 11, Grade 60 rebar, when the minimum stress level was 17.5 ksi.

1.2 Steel[1]

Fatigue of steel structures may cause progressive degradation and is initiated by plastic deformation within a localized region of the structure. A nonuniform distribution of stresses through a cross-section may cause a stress level to exceed the yield point within a small area and cause plastic movement after the number of stress reversal cycles reaches the material's endurance limit. This is the maximum stress to which the steel can be subjected for a given service life. Such conditions will eventually produce a minute crack. The localized plastic movement further aggravates the nonuniform stress distribution, and further plastic movement causes the crack to grow.

The fatigue behavior of steel structures strongly depends on their surface conditions (e.g., whether they are polished or in an as-received condition). The fatigue strength of structural steel components is generally represented by a modified Goodman diagram as shown in Figures T-2 and T-3, which is generated from the S-N curves. The fatigue strength of structural steel decreases as the number of cycles increases until the fatigue limit is reached. If the maximum stress does not exceed the fatigue limit, an unlimited number of stress cycles can be applied at that stress ratio without causing failure.

2.0 EVALUATION

2.1 Conditions

Some of the internal structural components of the Auxiliary Building are subject to high cycle, low-level repeated load, such as equipment vibration load, during normal plant operation. The Auxiliary Building and its structural components are also designed for abnormal events such as seismic and hurricane loads that are regarded as low cyclic load condition. Such loads may not occur or may occur for a very short duration only a few times during the service life of the Auxiliary Building. Therefore, the fatigue damage of the Auxiliary Building and its structural components is not age-related.

2.2 Potential Aging Mechanism Determination

Fatigue is a potential aging mechanism for the following structural components of the Auxiliary Building because they could experience high frequency of low-level, repeated loads such as equipment vibration load:

- Concrete columns — LR functions LR-S-1, 5
- Concrete beams — LR functions LR-S-1, 5
- Ground slab and equipment pads — LR functions LR-S-1, 5
- Elevated floor slab — LR functions LR-S-1, 2, 5, 7
- Concrete walls — LR functions LR-S-1, 2, 4, 5, 6, 7
- Roof Slabs — LR functions LR-S-2, 4
- Steel columns — LR functions LR-S-1, 5
- Steel beams — LR functions LR-S-1, 5
- Crane Rail/Supports — LR function LR-S-1, 5
- Base plates — LR functions LR-S-1, 5
- Floor framing — LR functions LR-S-1, 5
- Roof framing/trusses — LR functions LR-S-1, 4, 5
- Steel bracings — LR functions LR-S-1, 5
- Platform hangers — LR functions LR-S-1, 5

- Decking LR functions LR-S-1, 5

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If the effects of fatigue were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

All internal concrete components of the CCNPP Auxiliary Building were designed in accordance with ACI-318-63.[3,4] The design code[3] limited the maximum permissible design stress level to less than 50 percent of static strength, which is less than the fatigue strength of concrete (55 percent of static strength). In addition, actual concrete stresses induced by cyclic loads during normal plant operation, such as those from machine vibration, are a small portion of the combined stresses resulting from static and dynamic loads. This means that the stress range (magnitude of stress fluctuation) is also small and within the limit that yields extremely long fatigue life (> 10^7 cycles, which is equivalent to infinite life), as shown in Figure T-1.

All structural steel components in the Auxiliary Building were designed in accordance with American Institute of Steel Construction (AISC-1963) specification.[4,5] For the design of steel members and connections subject to repeated variation of live load stress, this specification[5] requires that consideration be given to the number of stress cycles, the expected range of stress, and the type and location of a member or detail. For life cycles of more than $2x10^6$ loading, the maximum stress may not exceed two-thirds of the basic allowable stress provided in Sections 1.5 and 1.6 of the AISC specification,[5] which is equivalent to 40 percent of the material yield strength.

ASTM A-36 carbon steel is typically used for all structural steel components in the Auxiliary Building.[4] As shown in the fatigue strength curves in Figures T-2 and T-3, the fatigue limit for as-received A-36 steel is about 20 ksi at a life cycle of approximately $2x10^6$, which is about 55 percent of the material yield strength. The maximum design stresses of all steel components were limited to 40 percent of material yield strength and are less than the material fatigue limit. Again, the actual steel stresses induced by cyclic loads are a small portion of the combined stresses resulting from static and dynamic loads.

2.5 **Plausibility Determination**

Based on the discussion in Section 2.4, fatigue will not degrade the structural components listed in Section 2.2. Therefore, fatigue is not a plausible aging mechanism for any structural components of the Auxiliary Building.

2.6 **Existing Programs**

There are no existing programs at CCNPP that are designed specifically to identify or to repair the damage to structural steel components due to fatigue. Since fatigue is not a plausible aging mechanism that could degrade the Auxiliary Building structural components, no management program is necessary.

3.0 CONCLUSION

Some concrete components in the CCNPP Auxiliary Building are subject to high cycles of low- level repeated load. These components were designed in accordance with ACI-318-63[3], which limits the maximum design stress to less than 50 percent of the static stress of the concrete. The concrete fatigue strength is about 55 percent of its static strength at the extremely high cycles (>10^7 cycles) of loading. Therefore, fatigue will not degrade any concrete components in the Auxiliary Building and requires no further evaluation.

Steel components in the Auxiliary Building subject to high-cycle (>10^5 cycles) loading conditions were designed in accordance with the AISC-63 specification.[5] The maximum stress in steel components and connections is smaller than the fatigue limit of steel. Fatigue degradation will have no adverse effects on the continued safety function performance during the license renewal term and requires no further evaluation for all structural steel components in the Auxiliary Building.

4.0 RECOMMENDATION

Fatigue is not a plausible aging mechanism for the structural components in the Auxiliary Building. Therefore, no further evaluation or recommendation is necessary.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Consideration for Design of Concrete Structures Subjected to Fatigue Loading," American Concrete Institute, ACI 215R-74, 1986.

3. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

4. Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2, by Bechtel Power Corporation, Revision 0, August 2, 1991.

5. "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," American Institute of Steel Construction, 1963.

6. Brockengrough, R.L., and Johnson, B.G., *Steel Design Manual*, United States Steel Corporation.

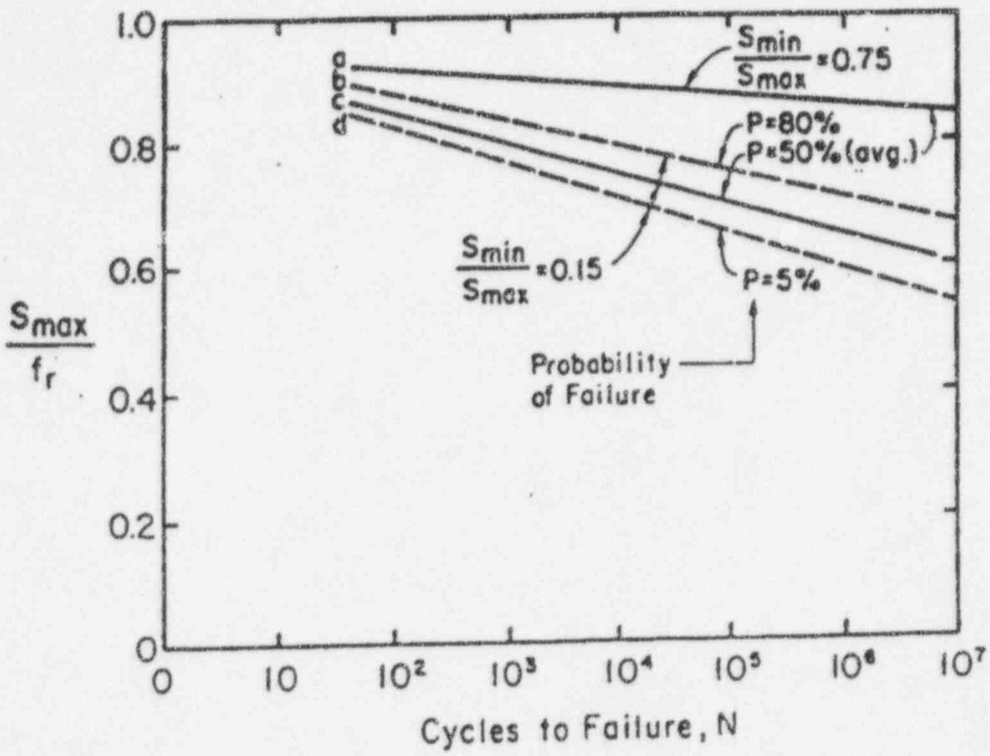

Figure T-1

Fatigue Strength of Plain Concrete Beams
(Source: Reference 2)

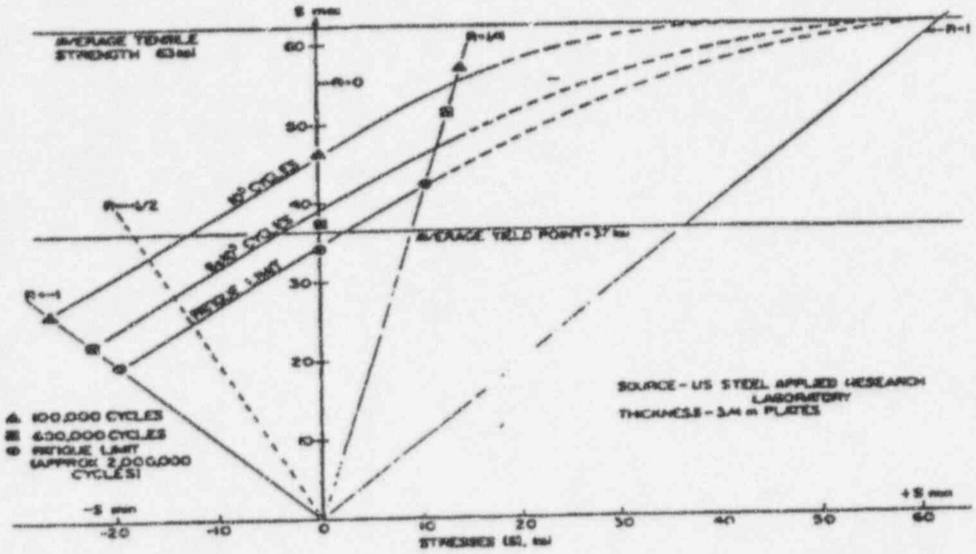

Figure T-2

Fatigue Strength of As-Received A36
Structural Carbon Steel
(Source: Reference 6)

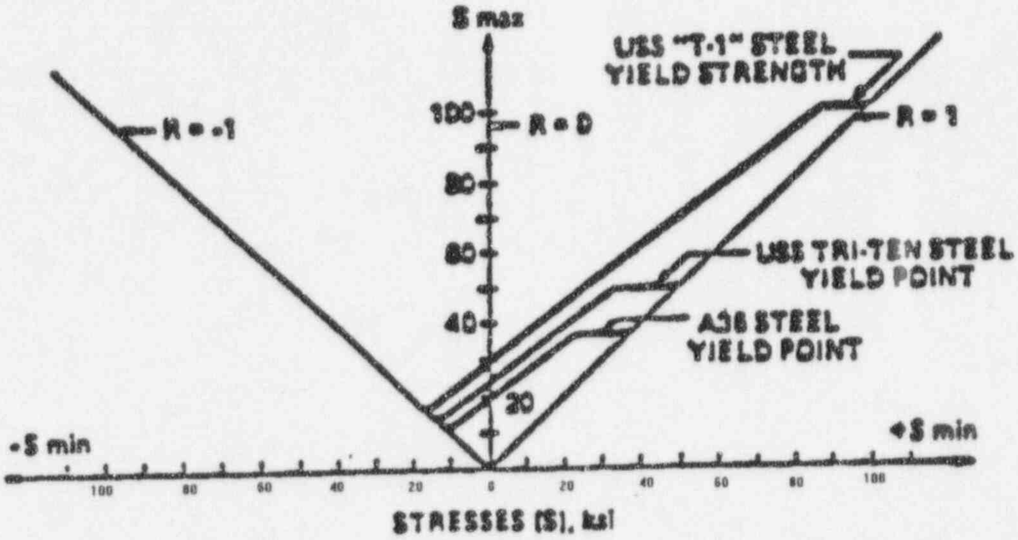

Figure T-3

Fatigue Strength of Transversely Groove-Welded
Structural Steel Plates at 2X10^6 Stress Cycles
(Source: Reference 6)